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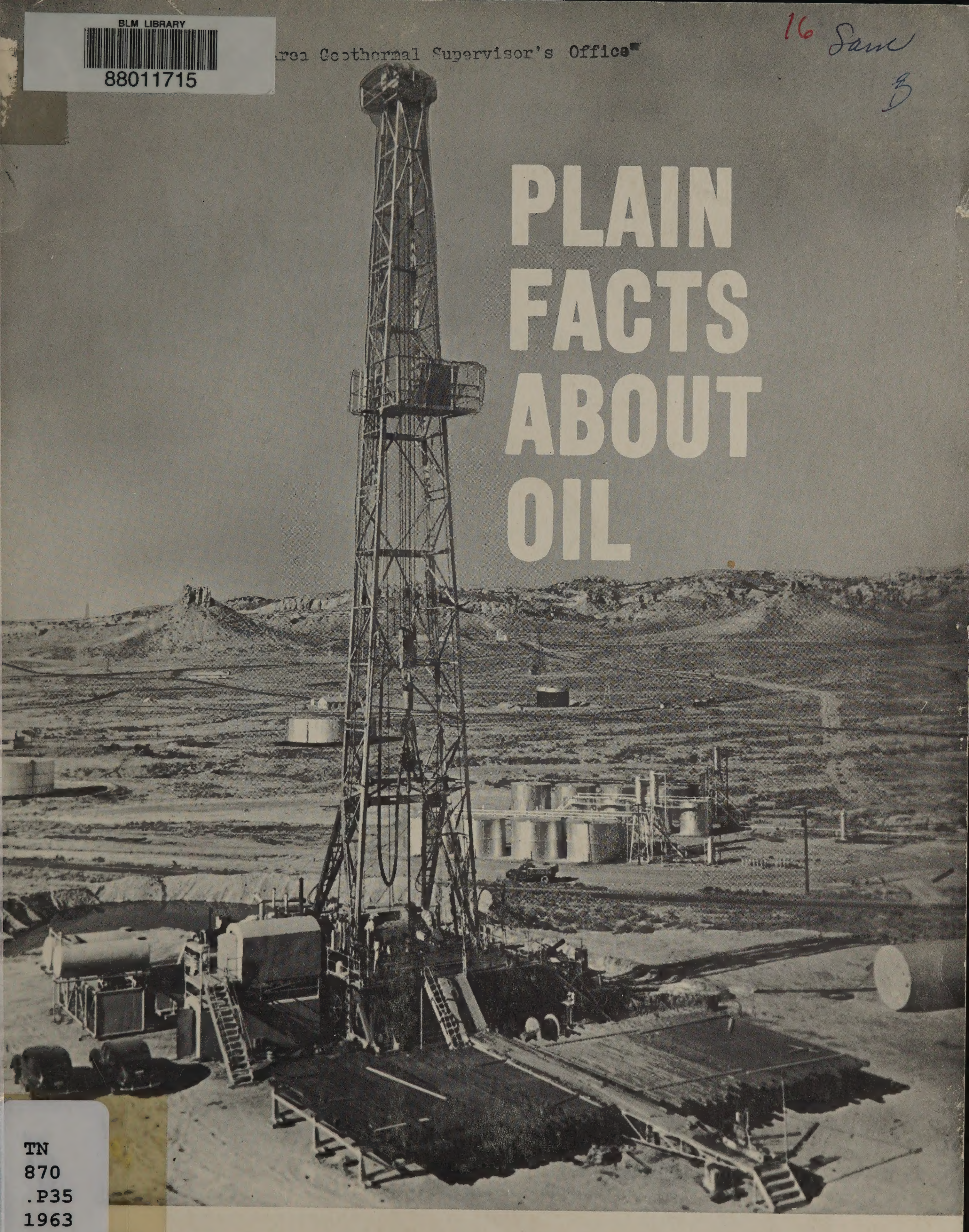
PLAIN FACTS ABOUT OIL



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AMERICA'S NATURAL RESOURCES

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.

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PLAIN FACTS ABOUT OIL

March 3, 1849

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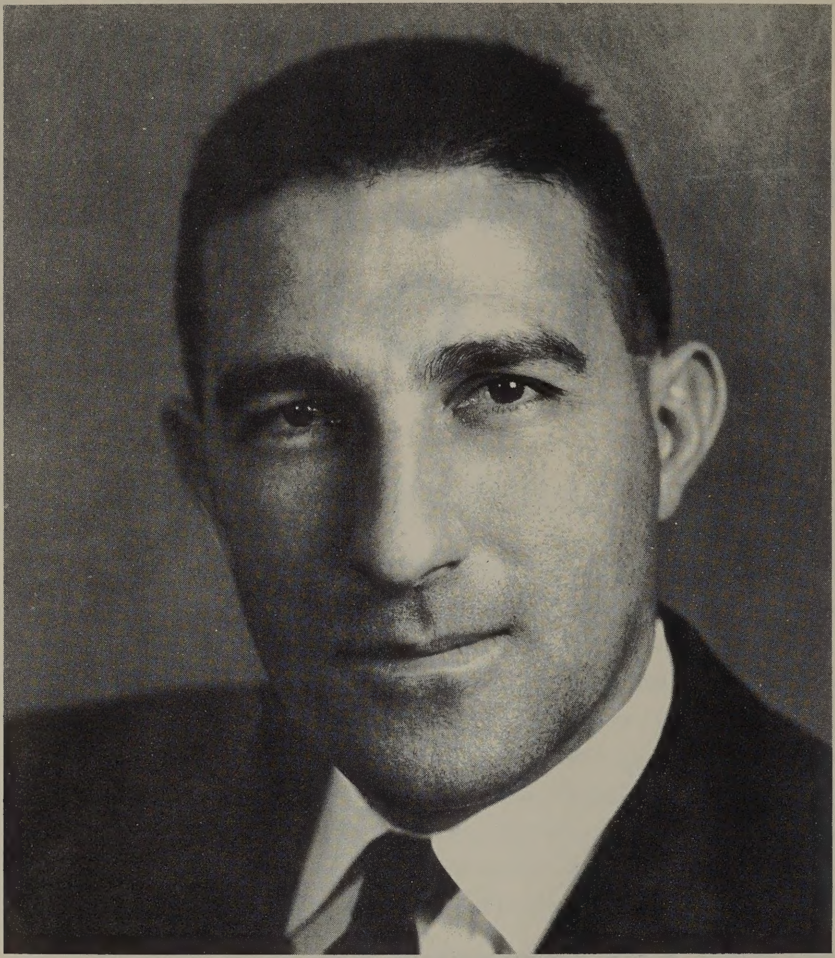
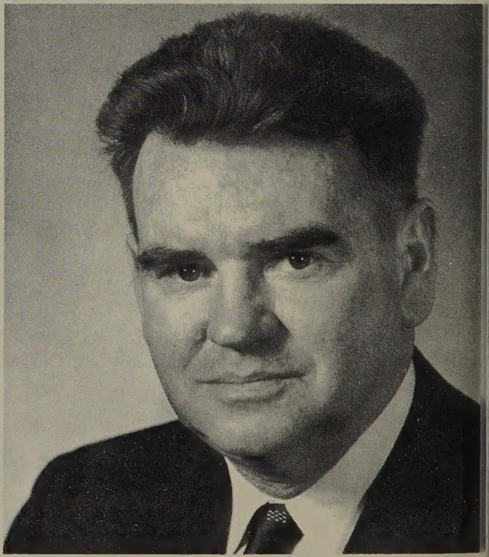


Stewart L. Udall
Secretary of the Interior



John M. Kelly
Assistant Secretary—Mineral Resources

Petroleum—Giant Pace Setter in U.S. Economy

Since the beginning of commercial production of petroleum in the United States in 1859, the search for, the development, and the utilization of petroleum has developed into one of the Nation's most important and essential industries. It employs approximately one and one-half million persons of every type and skill. The petroleum industry has developed several highly specialized professions and has probably contributed as much, both directly and indirectly, to the betterment of the American standard of living as any other single industry. It has brought wealth to many people and has contributed vast amounts in taxes to Federal, State and Municipal governments and has benefited the country at large through providing highways, schools and public improvements of every kind.

Stewart L Udall

Secretary of Interior

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Geology holds key to vast undiscovered petroleum reserves locked in the earth many millions of years ago.

Plain Facts About Oil

What Is Oil?

Oil or *crude petroleum* is commonly referred to as a liquid mineral. It is found at or beneath the surface of the earth, and is generally believed to have originated from the slow distillation of marine animal and vegetable matter over many centuries. It is composed of hydrogen and carbon, and is known as a hydrocarbon. Oil is not, however, a simple hydrocarbon, but it is a mixture of hydrocarbons. It is a chemical combination of two elements—hydrogen, a gas, and carbon, a solid—which combine in countless, complex and varying proportions of each element. In crude oils the amount of hydrogen varies from 10 to 15 percent and carbon from 80 to 89 percent. Oil is usually found mixed with natural gas, and sometimes salt water, within a porous formation varying from 1 to 500 feet in thickness (like ink in porous blotting paper) in the sedimentary layers of the earth's crust. As will be more fully explained later, the natural gas plays an important part in the production of crude petroleum in addition to being itself a valuable commodity.

The characteristics of different types of crude oil vary widely. Some are classified as asphaltic base; some are classified as paraffin base, and some as intermediate base. Some crude oils are light and highly fluid; others are thick and highly viscous. The colors range from almost water white through light amber and green to black. Since gasoline is in great demand, oils with a high gasoline content are generally higher priced.

The importance to us of this valuable mineral can be better realized if we stop to consider the effect upon our everyday life if we were suddenly deprived of it. Consider the millions of automobiles, trucks and buses that would stand useless; the thousands of commercial and fighting aircraft that would be grounded; the thousands of war and merchant ships that would lie motionless; the millions of homes, offices and factories that would be without heat and light. Our life as we know and enjoy it in this great Nation would be drastically curtailed without petroleum and its many products.

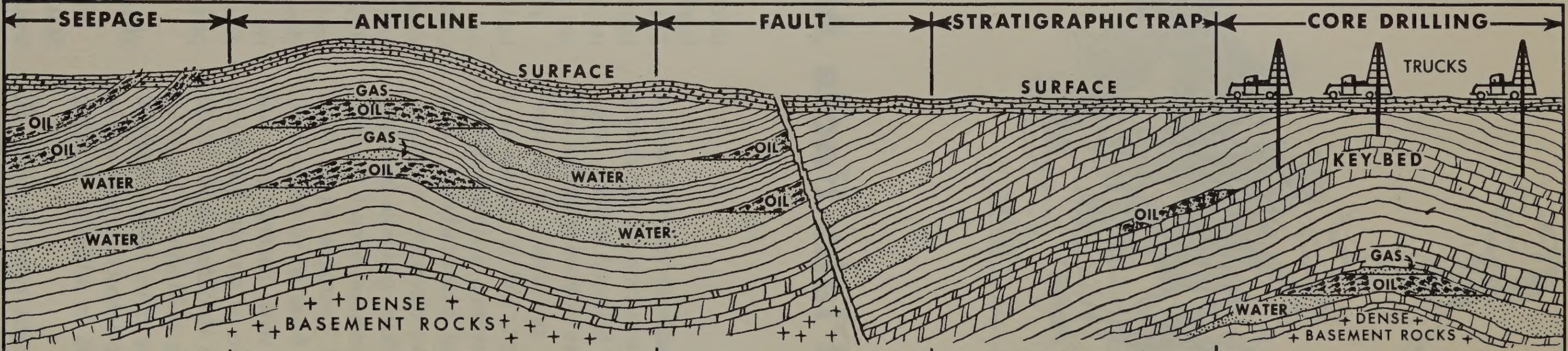
How Oil Is Created

The first commercial production of oil in the United States was in 1859, and since that time much has been learned of the occurrence of oil and the manner in which the great deposits were accumulated at various depths below the surface of the earth. There is gen-

The
SEARCH FOR OIL IS NEVER-ENDING

Porous rocks, such as sandstone, act as reservoirs for gases and liquids if their escape is prevented by some geological condition that acts as a seal. Gas, being the lightest, tends to accumulate in the top of the reservoir, just like the bubble in a level. Lighter than water, oil will in time separate from the water with which it was mixed at time of origin and slowly accumulate above and apart from the water that underlies and surrounds the oil. When porous rocks are tilted and folded, reservoir conditions suitable for the accumulation of petroleum are provided.

Petroleum, which includes both crude oil and natural gas, is found only in porous rocks, usually of sedimentary origin. Oil and gas are usually found together, but natural gas may occur separately. Some of the more common types of petroleum accumulation and the methods used to locate them are shown on this page.



Surface seepages and oil springs located the sites of the first oil wells and many later ones. As all known surface seepages in the United States were located and drilled years ago, more complex methods of finding oil were developed and adopted long since.

The anticline is, in its simplest form, a dome caused by upfolding of rock strata. Oil and gas are trapped in porous structures at the tops of these domes, with impervious strata above and below the porous rock layer. In most reservoirs, the oil floats on salt water, which prevents dispersion of the oil downward. The anticline exists in many varied forms, but all are the result of folding.

Faults result from a break or slip in the earth's rock crust. When a fault places a porous stratum against an impervious one, a natural petroleum trap is formed. Oil may be found on either or both sides of a fault at varying depths.

Most difficult of all oil-bearing structures to locate is the stratigraphic trap. No pronounced up and down folds of rock strata are present, the trap being formed by changes in the porosity of the formation. Thus, none of the scientific devices now in use to search for potential oil structures gives a clear clue to the existence of a stratigraphic trap. They are located only by exhaustive geological study, using every particle of information that can be gleaned about the area under consideration. The great East Texas field, largest in the United States, is a stratigraphic trap.

Core drilling is one of the methods by which the petroleum geologist seeks to peer beneath the surface of the earth to locate possible oil-bearing structures. It is based upon the probability that the folds found in the rock strata closest to the surface are continued in approximately the same pattern at greater depths. Small portable drilling tools are used to penetrate surface soils and take cores, or rock samples, from the topmost rock layers. By drilling a series of cores over a given area, a reasonably accurate picture of the probable subsurface geology can be obtained. Similar information is obtained by correlating the "logs" or records of all wells drilled in a given region and mapping from these the probable underground structure.

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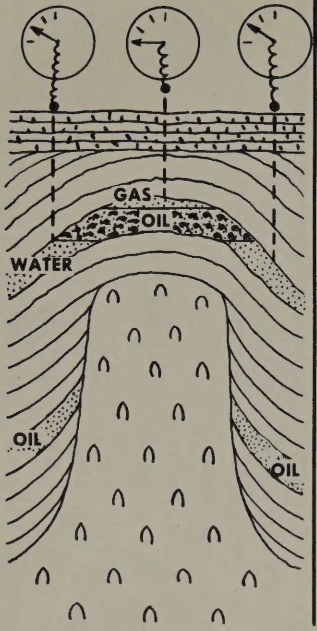
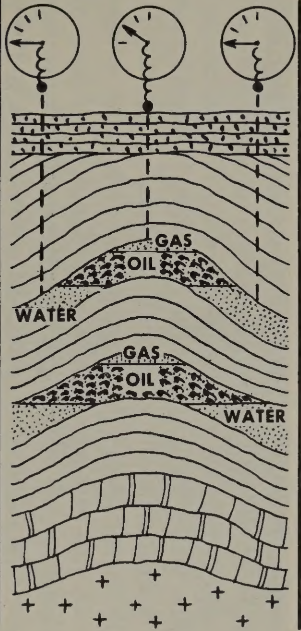
Today—Complex Scientific Devices Delve Deep Into The Earth In The Ceaseless Quest For Oil.

GRAVIMETER



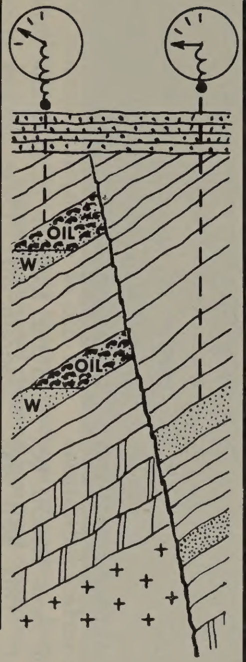
SALT DOME

Gravity is slightly less over the salt dome because salt is lighter than the surrounding rocks.



ANTICLINE

Gravity is slightly stronger over the top of the anticline because the denser basement rocks are nearer the surface.

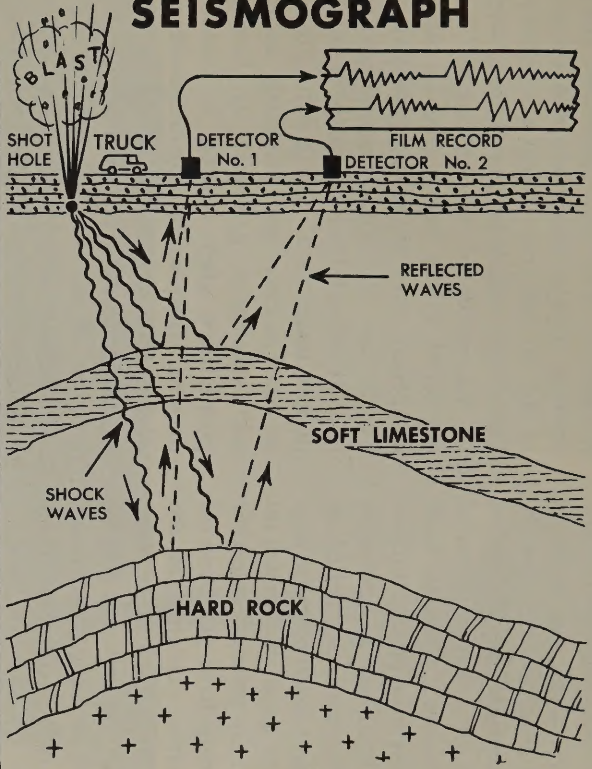


FAULT

Gravity is slightly greater on the raised side of the fault because dense rock is closer to the surface there.

Geological structures such as those shown above cause slight variations in the force of gravity. The gravimeter detects these minute variations and therefore discloses the presence of possible oil-bearing structures. The latest models can detect variations as small as one one-hundred-millionth of the total force of gravity. While the principle of the gravimeter is well understood, the actual mechanism is an expensive maze of delicate parts and jewel bearings. The salt dome, shown at left, is a prolific source of oil accumulation along the Gulf Coast of Texas and Louisiana.

SEISMOGRAPH



The seismograph is the foremost scientific instrument now in use for the location of hidden structures which may contain oil or natural gas. Since its adoption in the mid-1920's, millions of acres of land in the United States have been mapped from its findings. The seismograph was originally devised to record earthquakes. In oil prospecting, a dynamite blast is set off which sends shock waves down into the earth. As they strike rock formations, the waves are reflected back to sensitive detectors. Soft formations reflect weakly on the recording film and hard formations make larger jogs. The elapsed time between the blast and the return of the shock waves to detectors measures depth.

eral agreement among geologists who have made extensive studies of the subject that the various layers of sand and porous rock in the earth which now contain our deposits of crude oil were at one time, millions of years ago, on the floors of great bodies of water. It is well known that there is deposited on the bottom of all large bodies of water a great accumulation of marine life and other organic matter. Chemists have proved that such organic matter may be transformed into oil and gas by long continued heat and pressure, aided by bacterial action. Pressure was applied to the accumulation of such organic matter by the deposition of silt and sediments to great thicknesses on top of the organic matter. This pressure, together with the heat of the earth, may have produced oil and gas from the organic matter deposited in the sediments. Gradually, over long periods of time (thousands of years), some of the oil and gas so formed migrated into the porous rock and accumulated into sufficient quantities to create commercial oil deposits.

How Oil is Located

The first oil well drilled in the United States was drilled at a particular spot because surface indications led the driller to believe that oil was present beneath the surface of the ground. This well was drilled in the year 1859 near Titusville, Pennsylvania, by Colonel Edwin L. Drake, who did not fully realize the importance of his discovery. For many years prior to the drilling of the Drake well, oil had been recovered in small quantities from the surface of creeks and water wells in the Titusville area. The first white men to visit that area of the country found the Indians making use of oil seeping to the surface of the ground. The oil was first used by the white settlers as a medicine, and some of the enterprising traders of the country had built up a business of bottling the oil and peddling it about the country as a cure for aches and pains. However, a few years prior to Drake's discovery, tests had been made which revealed that a good lamp oil could be made from crude petroleum.

It is a matter of historical interest to note that Colonel Drake's well was drilled to a depth of 69½ feet, which would now be looked upon by oil men as a mere scratch upon the surface of the earth.

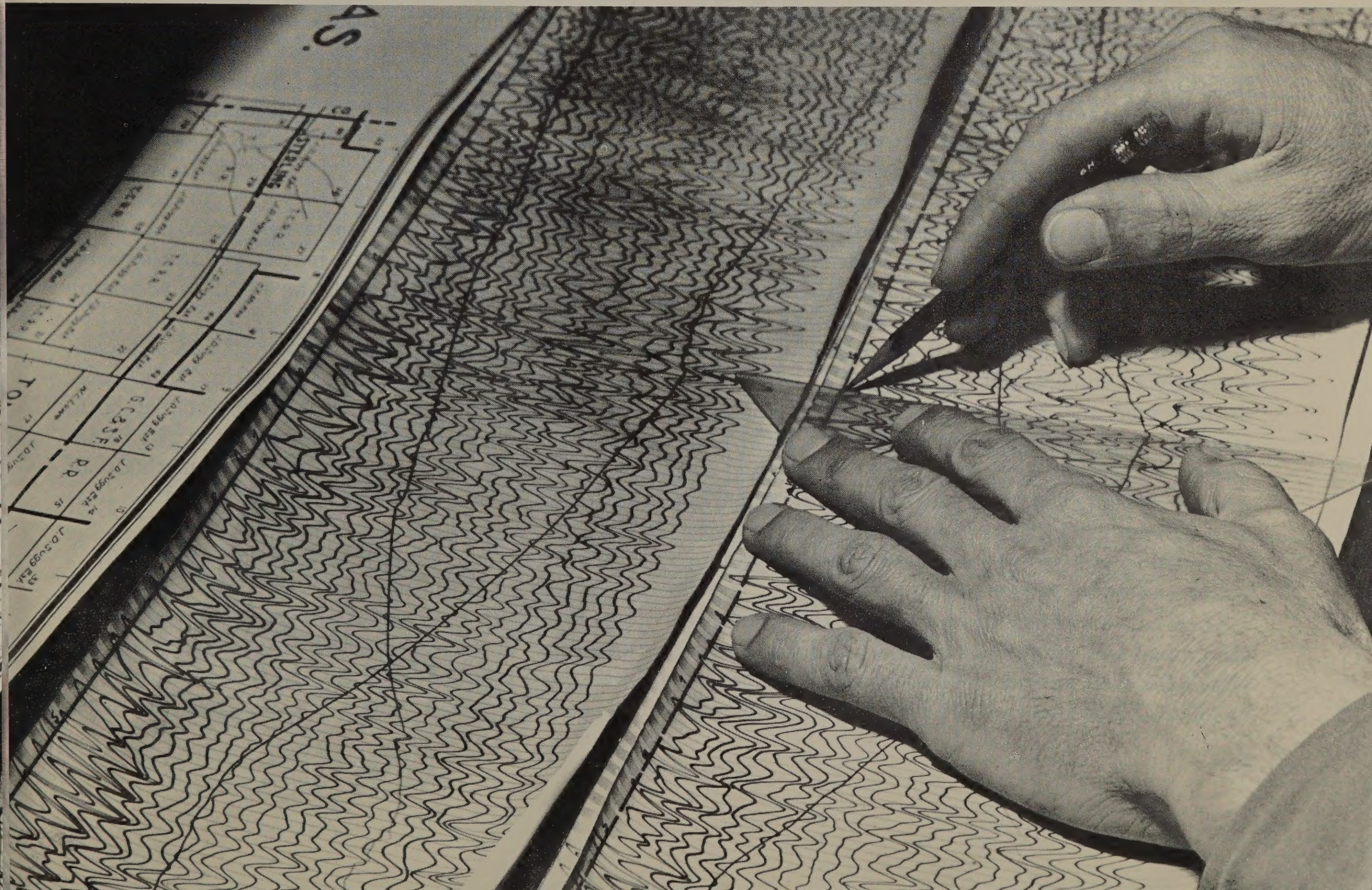
Much progress in the scientific search for oil has been made since 1859. Highly skilled and scientifically trained professions have developed from the necessity for locating deposits of crude oil thousands of feet below the surface of the earth where there are little or no surface indications to guide the prospector. Petroleum geologists and geophysicists perform highly important and necessary functions in the oil industry. With the increase in scientific knowledge, which developed along with the increase in discoveries of oil, geological proficiency has developed to the extent that in the present day a competent and experienced geologist can determine, by the use of scientific equipment, whether there is a likelihood that a deposit of oil lies thousands of feet underneath. Quite naturally, geology is not an exact science, and frequently an area picked by an experienced geologist as having oil-bearing possibilities, after drilling, is found to be unproductive. However, geological information and knowledge reduce chances of failure in the search and, in doing so, makes a valuable contribution to the progress of the oil industry.

In addition to indications on the earth's surface, which furnish clues to the geologists in locating oil deposits, there are some subsurface indications which, when available, are valuable in this science. Information of this type is obtained from water wells, mine shafts, records of previously drilled oil or water wells, information obtained from core drills and by the use of geophysical devices which are now used in the location of favorable structures which may contain oil. These devices consist of instruments designed to measure the magnetic attraction (by the magnetometer) of rocks and various strata beneath the ground, the pull of gravity (by the torsion balance and the gravimeter) exerted by subsurface formations, and the speed and direction of various measurable vibration waves (by the seismograph) within the earth. When oil is found in a locality having certain definite surface contours or certain definite subsurface strata, the geologist and geophysicist then search for a locality with similar surface or subsurface indications, with the hope that oil may be contained in the formations underlying them.

Drilling for Oil

When Colonel Drake drilled his well in 1859, the drilling methods were very crude. His well was drilled with handmade tools somewhat similar to the cable-tool rigs which are used today for shallow drilling. In this method of drilling, a derrick, from 40 to 80 feet in height, is erected, from which a heavy steel drilling bit is suspended on a wire cable. This bit is raised and lowered causing it to pound

Top—Seismograph crew observes shot-hole in range country, southwest Wyoming. Bottom—Computer calculating reflections on seismograph record obtained from field operations.



and pulverize the rocks. The cuttings are intermittently removed from the hole by a long (20–35 foot) thin gauge bucket, known as a "bailer." As the industry progressed, and drilling depths increased, improved methods were developed. The simple cable-tool method of drilling has been virtually replaced by the now popular rotary method.

The *rotary rig* was first used around 1900 in the drilling of oil wells in the Spindletop Field near Beaumont, Texas. The modern rotary drilling rig has many component parts. The most conspicuous part is the derrick, ranging in height from 89 to 200 feet (depending upon the well depth), which is much higher and heavier than the one used on cable-tool rigs. Instead of the bit being attached to a wire cable, it is screwed onto heavy pipe called "drill pipe," to which additional lengths or sections (stands) are added as drilling progresses. The area covered by the base of the derrick is floored with heavy timbers or grated metal on which the rotary table and other drilling machinery are placed. The rotary table performs the function of rotating the drill pipe, thus causing the bit at the lower extremity of the drill pipe to drill through the formation.

A chemically treated drilling fluid (mud) is pumped down through the drill pipe and through the bit, up through the space between the drill pipe and the wall of the hole which has been cut, to the surface where it is screened and tested before being again pumped back into the well in continuous circulation.

The circulating drilling fluid serves the following functions: (a) acts as a lubricating and cooling agent for the bit as it cuts through the hard rock formations; (b) jets the cuttings off the bottom of the hole as they are made by the bit and floats them to the surface; (c) seals the wall of the hole to prevent caving; and (d) serves as a hydrostatic weight to keep any high pressure gas, oil or water zones from blowing from the hole uncontrolled. Often, during the drilling of a well, high pressure gas, oil or water zones are penetrated by the drill. In such instances, it is often necessary to thicken and increase the weight of the drilling mud and increase the pressure of the mud pumps enough so that the pressure can be held back and not escape into and up the hole. If this pressure gets out of control, a large valve at the surface known as a "blow-out preventer" is closed to prevent the gas or oil from escaping into the atmosphere, causing waste and a fire hazard.

There are numerous strata between the surface of the ground and the particular oil or gas formation to which the well is to be drilled, in which water, gas or oil are often found, or all three simultaneously in various amounts. Obviously, when it is desired to drill through these strata to a lower formation, something must be done if the gas or water is not to interfere with the progress of the drilling. These problems are dealt with by controlling the viscosity and weight of the mud pumped into the well, or by installing casing in the well to seal off these formations so that the water, gas or oil in them cannot escape into the well. The casing is steel pipe varying in diameter from three to fourteen inches or sometimes larger. Some deep wells may have as many as five different "strings" of casing installed in them before the producing sand is reached.

In order to hold the casing in place and to "seal off" a water or gas formation effectively, it is customary to set or land the casing through and below the formation and then cement the casing in the hole. This is done by pumping a soft cement mixture down through the casing with sufficient force to be forced upward between the outside of the casing and the inside of the hole, sealing off the formation to be protected. Generally, the last string of casing put into the well penetrates the producing formation and is called the "production string." After the cement is cleaned out inside the casing, to a predetermined depth (usually below the depth of the producing formation), the casing is then perforated.

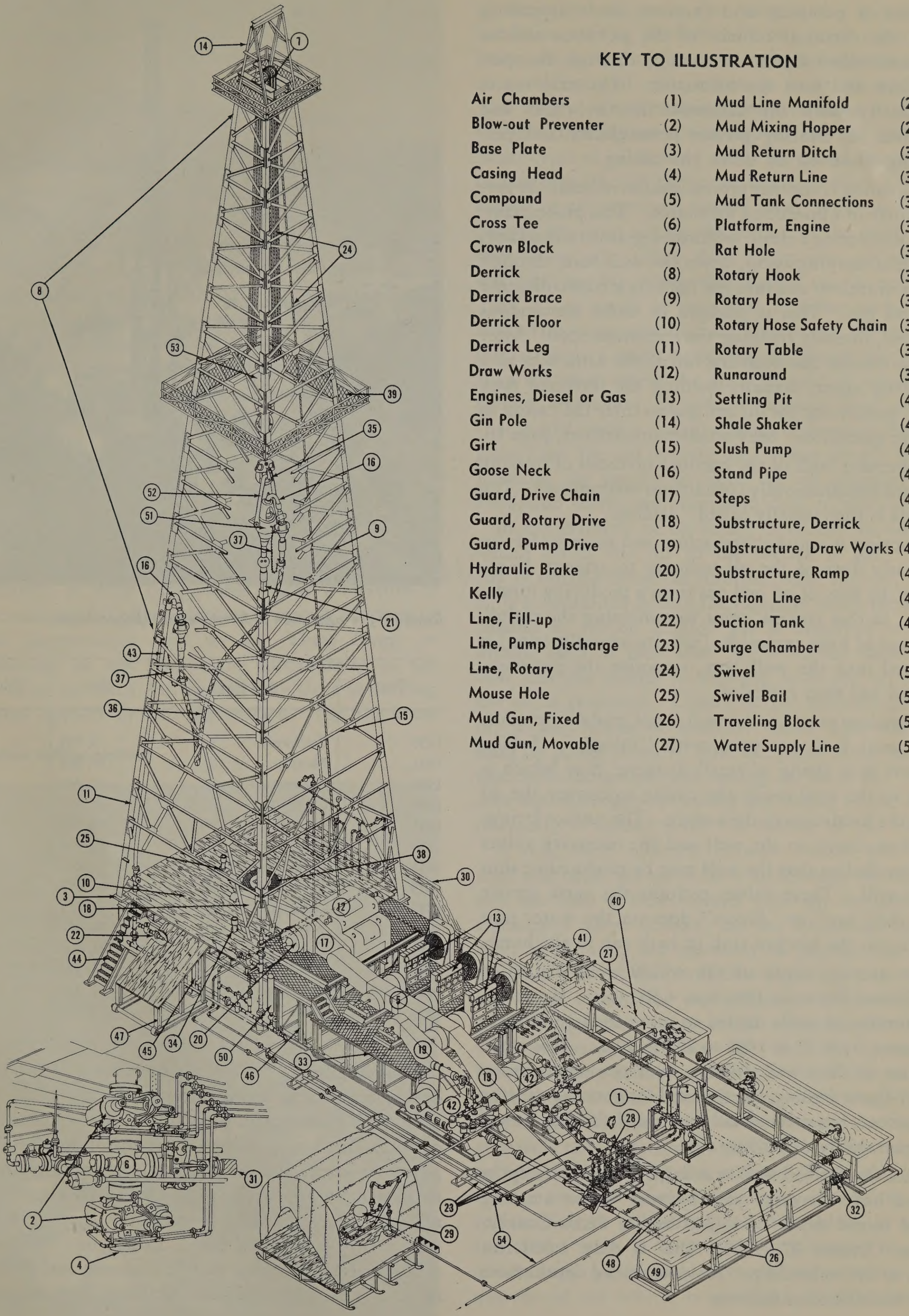
Perforating is done by a (perforating) gun or a jet perforator which is lowered down the hole on a wire line to the depth, opposite the oil or gas zone. The gun fires bullets and the jet perforator fires shaped charges of high-temperature, high-velocity gases through the casing and cement to open passages for the flow of oil and gas. Various sizes of perforations and depths of penetration into the formation can be obtained, depending upon the type of tool used, kind of formation encountered and other prevailing conditions. A more recent type of perforating service has been developed utilizing an abrasive jetting technique.

If the pay-zone is not as productive as expected, there are several methods of "treating" the zone, either by chemical or physical stimulants, or both, so that the flow of oil to the surface might be increased. The chemical and physical methods of treating the productive zone are described as acidizing, fracturing and sometimes "shooting."

If the pay-zone happens to have low permeability, then the oil will not come forth in commercial quantities. If the productive zone happens to be limestone, dolomite or a sandstone having a high lime content, then acidizing is likely to increase the porosity of the zone. The acidizing operation

KEY TO ILLUSTRATION

Air Chambers	(1)	Mud Line Manifold	(28)
Blow-out Preventer	(2)	Mud Mixing Hopper	(29)
Base Plate	(3)	Mud Return Ditch	(30)
Casing Head	(4)	Mud Return Line	(31)
Compound	(5)	Mud Tank Connections	(32)
Cross Tee	(6)	Platform, Engine	(33)
Crown Block	(7)	Rat Hole	(34)
Derrick	(8)	Rotary Hook	(35)
Derrick Brace	(9)	Rotary Hose	(36)
Derrick Floor	(10)	Rotary Hose Safety Chain	(37)
Derrick Leg	(11)	Rotary Table	(38)
Draw Works	(12)	Runaround	(39)
Engines, Diesel or Gas	(13)	Settling Pit	(40)
Gin Pole	(14)	Shale Shaker	(41)
Girt	(15)	Slush Pump	(42)
Goose Neck	(16)	Stand Pipe	(43)
Guard, Drive Chain	(17)	Steps	(44)
Guard, Rotary Drive	(18)	Substructure, Derrick	(45)
Guard, Pump Drive	(19)	Substructure, Draw Works	(46)
Hydraulic Brake	(20)	Substructure, Ramp	(47)
Kelly	(21)	Suction Line	(48)
Line, Fill-up	(22)	Suction Tank	(49)
Line, Pump Discharge	(23)	Surge Chamber	(50)
Line, Rotary	(24)	Swivel	(51)
Mouse Hole	(25)	Swivel Bail	(52)
Mud Gun, Fixed	(26)	Traveling Block	(53)
Mud Gun, Movable	(27)	Water Supply Line	(54)



Typical power rig

consists of pumping acid (various kinds depending upon the chemical content of the pay-zone and its characteristics) down the casing, through the perforations and into the formation. The acid reacts chemically with the carbonate in the rocks and dissolves it, creating greater permeability and permitting more oil to enter the casing.

Fracturing is another process used to increase the permeability of a producing formation. This process consists of injecting a clean, uniformed-grained silica sand, in a fluid carrying agent, down the well bore, through the perforations and into the hard rock containing the oil and gas. This is pumped in under tremendous pressure, literally cracking the formation open. After the formation has been fractured, the sand acts as a propping agent, actually holding the fractured rock open, permitting the oil and gas to enter the casing in greater quantities. See Formation treatment, page 10.

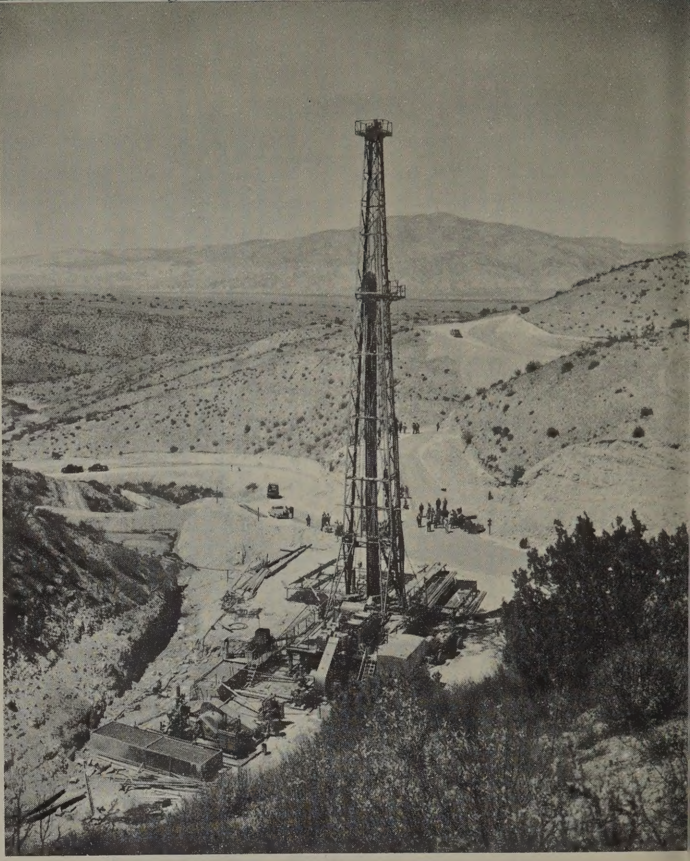
Sometimes both of the previous methods of treating are used simultaneously (conditions warranting). The process is then usually called "acidfrac."

Shooting is another operation used more widely in the early days of the oil industry to attempt to increase the flow of oil and gas from a producing formation. In this process, prior to cementing the casing, a charge of high explosives (usually nitroglycerine) is lowered into the well bore, opposite the pay-zone, tamped and then exploded.

In modern practice, the well is not ready for production until it is equipped with "tubing." Tubing consists of a string of small diameter pipe which is hung in the well inside the casing to convey the oil from the formation to the surface. The surface fittings are then placed on the well and the necessary valves are installed so that the well may be produced or shut in at will. These valves perform the same service that the "tap" or "faucet" does on the water pipe leading to the kitchen sink or bath tub in the home.

The average depth of the 46,179 wells drilled in the United States in 1962 was 4,300 feet. However, the number of wells drilled to more than 15,000 feet increased from 12 in 1951 to 276 in 1962. This rapid increase in deep well drilling, plus the requirements for off-shore drilling and the need for portable drilling equipment, has substantially increased the size, power and portability of drilling rigs.

Since the first oil well was drilled, the total depths drilled have increased year by year to the amazing world record depth of 25,340 feet in Pecos County, Texas, October 27, 1958. This is only 1,060 feet short of five miles deep. Previous record depths have been established as follows:



Rotary rig in operation in Southwestern United States

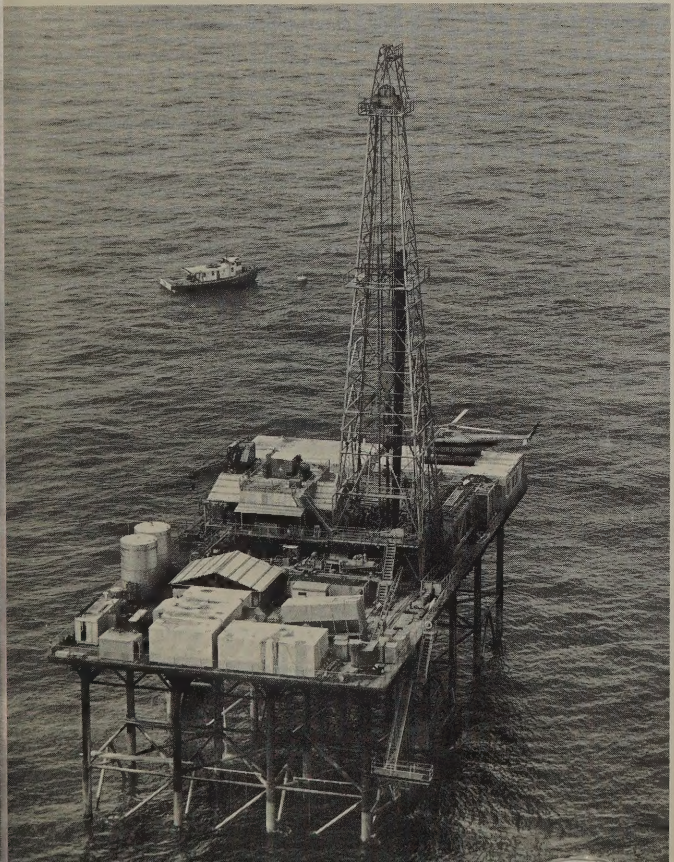
Year	Location	Feet	Miles
1930	California	9,753	1.8
1931	Mexico	10,585	2.0
1933	California	10,944	2.1
1934	California	11,377	2.2
1935	West Texas	12,786	2.4
1938	California	15,004	2.8
1944	West Texas	16,246	3.1
1945	Texas Gulf Coast	16,655	3.2
1947	Oklahoma	17,823	3.4
1949	Wyoming	20,521	3.9
1953	California	21,482	4.1
1955	Louisiana	22,570	4.3
1958	Oklahoma	24,004	4.5
1958	Texas	25,340	4.8

A modern heavy drilling rig rated for a 25,000 foot depth, comprising a steel derrick, rotary table and hoist with power plant weighing about 80 tons, two or three circulating pumps rated up to 1,500 horsepower or more, and other accessories representing a total weight approaching 200 tons, will cost one million dollars and drill three or four deep wells per year. This is for land-based operations. Off-shore drilling demands much more equipment and investment. The largest off-shore drilling ship designed to date (1962) will cost $4 million and will operate in waters up to 600 feet deep.

Production

In the early days of discovery, it was popularly believed that deposits of crude oil were in the form of lakes or pools in the reservoir. It was not long, however, before this theory was proved inaccurate and it became definitely known that oil deposits are, in fact, contained in porous or sponge-like rock, usually limestone or sandstone. It was also found that practically all deposits of oil are accompanied with natural gas which originated from the same organic matter as the oil. In many cases deposits of crude oil are surrounded by edge water or underlain by bottom water, these deposits of water usually being under pressure. The various sedimentary strata or formations of the earth are found in layers as in a layer cake, many layers extending laterally throughout many counties or even states. For example, in drilling an oil well the driller might first encounter a layer or stratum of sand (pervious), then a stratum of shale (impervious), next a stratum of limestone rock (often pervious), next a stratum of slate (impervious), and so on. These layers or formations do not always run horizontally to the surface of the earth, but instead may slant in varying degrees upward toward the surface. The thickness of the layers or strata also varies and a particular formation may be 100 feet thick at a point 1,000 feet below the surface of the earth and gradually thin out to a thickness of only a foot or so at the surface. This may also occur underground with no evidence of the thinning or disappearance at the surface. Many types of oil-bearing sands are found thousands of feet beneath the surface at one spot with a large supply of oil contained within them, while at other points they crop out on the surface of the earth and contain no oil. Often these formations are named after the locality where they appear on the surface. Thus it can easily be seen that if either surface or subsurface water should enter a particular oil-bearing formation at a point nearer the surface of the earth than the place where the oil is located, it would, in seeping downward, as natural physical laws require that it will, exert a certain amount of pressure (hydrostatic) on the oil which, in "water-drive" fields, provides the energy to force the oil through the formation to the well-bore and then to the surface.

Offshore drilling platform

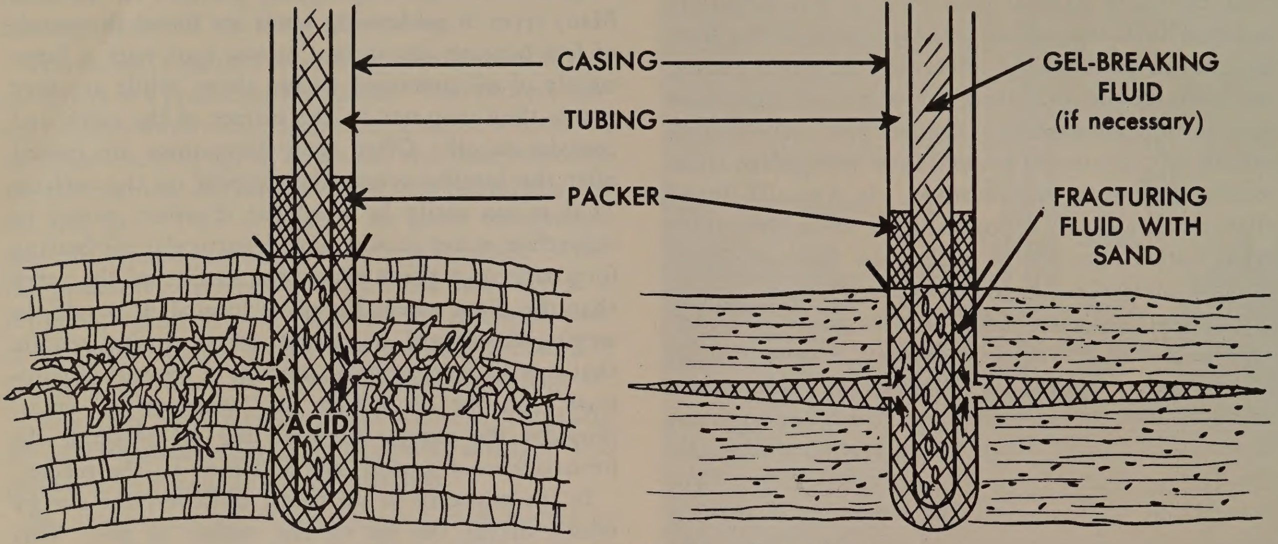


In the majority of oil fields, however, the energy which drives the oil to the surface is gas. This gas is usually found in solution with the oil; that is, it is contained within the liquid in much the same manner as carbon dioxide gas is dissolved in soft drinks, such as root beer. It is highly important that this gas remain in solution with the oil until the oil is produced. Otherwise the mobility of the oil is lost. Loss of mobility means that the oil loses its power to move from the pores in the formation into the casing and tubing of the well. If it does not move into the casing and tubing of the well, obviously it cannot reach the surface of the earth.

A well with sufficient pressure within the payzone will cause the oil to flow up through the tubing and out into a field storage tank on the surface. Opening a valve (choke) on the well-head equipment is the only act necessary to produce the oil. Obviously no oil well will flow forever because each time it is opened for production a certain amount of its energy from gas or water is expended, which will eventually exhaust the reservoir pressure. However, long before total exhaustion of the energy, there comes a time when there is only enough pressure of combined gas and water to cause the oil to flow from the formation into the well, but not enough to force it upward to the surface. When this time comes, artificial means of bringing the oil to the surface must be utilized. If gas is saved in the early life of the well, it is possible to postpone the use of artificial production methods and increase the amount of oil which is produced by the cheaper

FORMATION TREATMENT

Hydraulic fracturing and acidizing are very similar in many respects. Both involve pumping a fluid into a well to form or enlarge passages through which oil flows into a well from the pay formation. Acid does this through chemical action, while hydraulic fracturing does this by mechanically cracking the formation. Pressures in these processes range from low to very high values, depending on the kind of formation being treated.



(Passages and fractures magnified for illustrative purposes)

ACIDIZING

Used in treating producing zones that are composed of limestones or dolomites, or sandstones which contain a high percentage of limestone. Common procedure in acidizing is to inject the acid opposite the formation to be acidized, and apply pump pressure to the tubing. This pressure forces the acid into the formation where it eats out passages through which oil will travel into the well. Limestones are treated with the acid to take advantage of its dissolving power.

HYDRAULIC FRACTURING

Used to form cracks or fractures in tight producing formations. Thick fracturing fluid under high pressure and with entrained sand cracks open the rock along lines of weakness. The sand grains are carried into the cracks and hold the cracks open. The fracturing fluid is either a jellied oil or jellied acid.

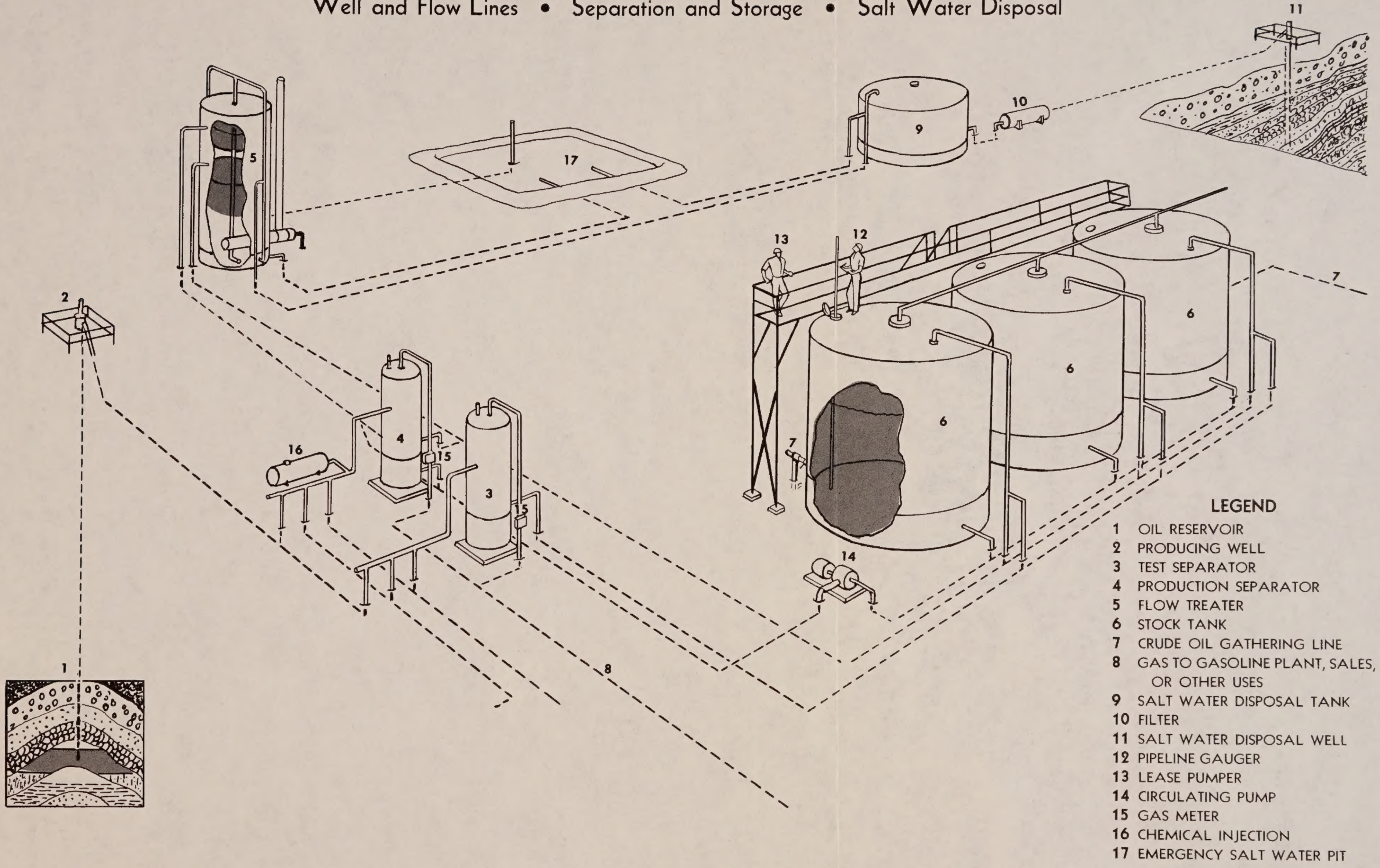
flow method. If gas is wasted, artificial lift must be used at an early date and a smaller total amount of oil is recovered. For this reason many people who are interested in conservation constantly seek ways to eliminate the waste of gas from oil wells.

There are a variety of ways for artificially producing wells and the usual method is by the use of a plunger pump. Basically the plunger pump consists of a standing valve, working barrel and a plunger. Older type tubing pumps were attached to the lower extremity of the tubing, but the insert or rod pumps are used almost exclusively today. The insert pump is attached to the bottom of a string of slender steel rods called "sucker rods" and is seated inside and at the bottom of the tubing. The upper extremity of the sucker rods is attached to a pumping jack or unit, which is on the surface. The operation proceeds in such a manner that the rods are raised and lowered in accordance with the speed of the power plant or prime mover on the pumping unit. This up and down motion of the rods activates the pump and the oil is lifted from the bottom of the well to the storage facilities on the surface. Some other types of lifting devices are the electrical subsurface pump, subsurface hydraulic pump, central power unit, gas lift and plunger lift.

As the oil is produced from the formation, there is produced with it a certain amount of natural gas which, as has been previously pointed out, is also a valuable commodity. Before storing the oil in the lease tanks for future removal, it is necessary to separate the gas from it. This is done by means of an oil and gas separator. A similar separator is used to separate salt water from the oil, if salt water is present in sufficient quantity. The gas, after being separated from the oil, is usually removed from the lease by means of a pipeline either for use as a fuel or for

FLOWING OIL PRODUCTION

Well and Flow Lines • Separation and Storage • Salt Water Disposal



LEGEND

1 OIL RESERVOIR
2 PRODUCING WELL
3 TEST SEPARATOR
4 PRODUCTION SEPARATOR
5 FLOW TREATER
6 STOCK TANK
7 CRUDE OIL GATHERING LINE
8 GAS TO GASOLINE PLANT, SALES, OR OTHER USES
9 SALT WATER DISPOSAL TANK
10 FILTER
11 SALT WATER DISPOSAL WELL
12 PIPELINE GAUGER
13 LEASE PUMPER
14 CIRCULATING PUMP
15 GAS METER
16 CHEMICAL INJECTION
17 EMERGENCY SALT WATER PIT

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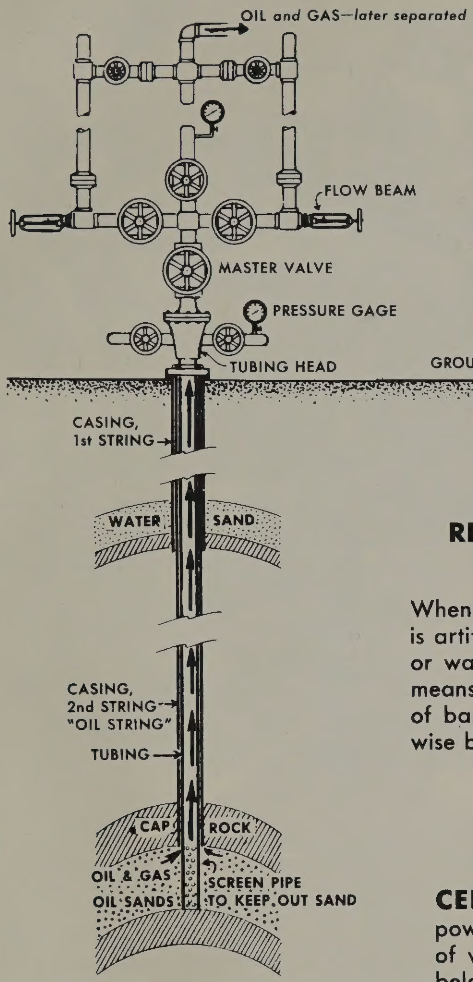
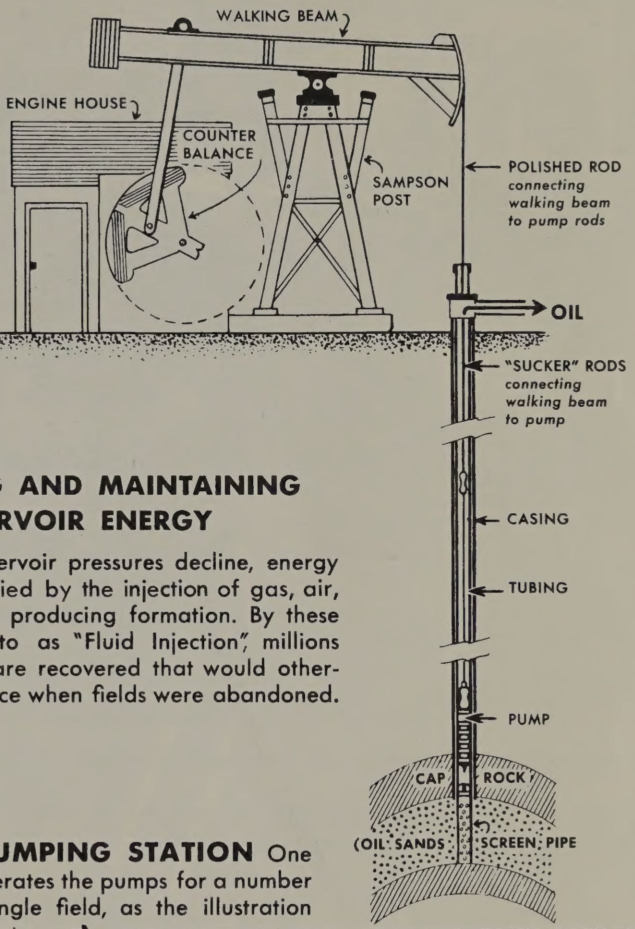
PETROLEUM PRODUCTION METHODS

FLOWING WELL Because of its resemblance to a Christmas tree, this is the name given to the collection of valves which controls a high-pressure well. In a flowing well the natural pressure below ground is sufficient to force the oil (mixed with gas and sometimes with water) through the tubing or "flow string," to the surface.



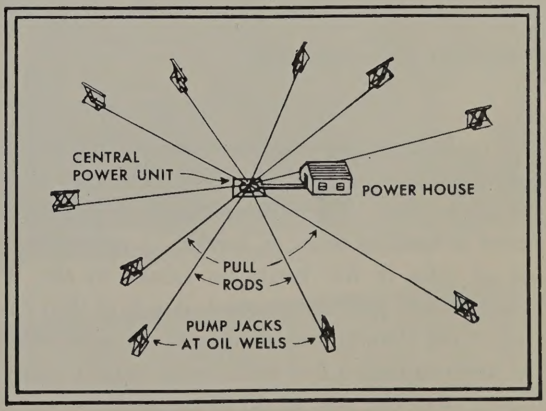
MECHANICAL PUMPING The illustration below demonstrates mechanical pumping which employs the principle of a simple suction pump. The walking beam, moved up and down by the crank, alternately lifts and lowers rods which operate the pump, or "working barrel," in the bottom of the well, lifting the oil to the surface.

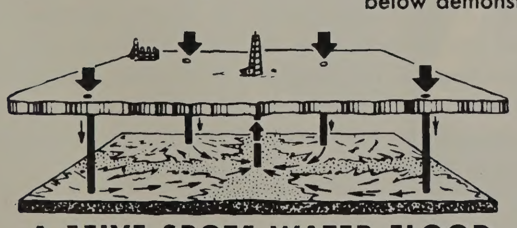


RESTORING AND MAINTAINING RESERVOIR ENERGY

When natural reservoir pressures decline, energy is artificially supplied by the injection of gas, air, or water into the producing formation. By these means, referred to as "Fluid Injection", millions of barrels of oil are recovered that would otherwise be left in place when fields were abandoned.

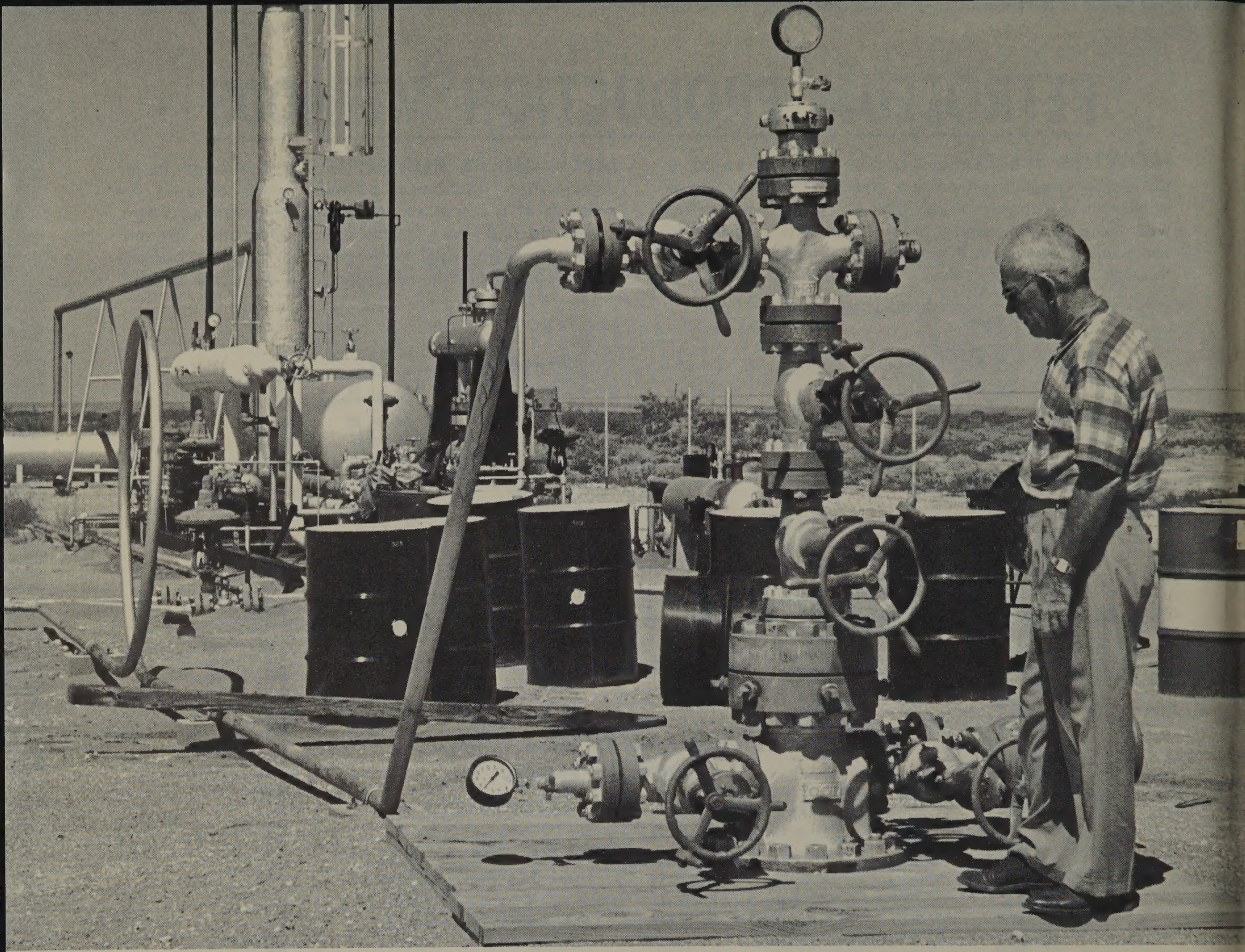
CENTRAL PUMPING STATION One power plant operates the pumps for a number of wells in a single field, as the illustration below demonstrates.





A "FIVE-SPOT" WATER FLOOD

If you consider each oil well as the center of a square, there is a water well at each corner of the square. The water, forced down and into the producing sand, carries oil with it from each point of injection toward the oil wells, thus flushing the reservoir. Pumps lift water and oil for separation on the surface.



Single-wing type of "Christmas Tree" at a gas distillate well

processing in a gasoline plant for removal of the remaining quantities of liquid contained in it.

Petroleum Transportation

Petroleum transportation has, of course, changed considerably since its early beginnings just prior to the Civil War. Early petroleum transportation consisted of hauling wooden barrels on wagons or by the use of rafts or flat boats on creeks in the Western Pennsylvania producing area. Roads of that day were little more than muddy trails and transportation costs for hauls of only a few miles were usually many times higher than the cost of oil at the well.

During the 1860's railroad construction proceeded at a rapid pace and resulted in a network of railroads in the Pennsylvania oil country. The first railroad tank car, consisting of large wood tanks on a flat car, was used in 1865. The heavy expense of hauling oil to railheads by wagon promoted the idea of moving oil by pipeline. The early history of pipelines is filled with colorful stories of the struggles of competing teamsters and railroads to halt pipeline construction.

The first barges used for hauling petroleum were wooden scows carrying oil in barrels and later directly in their hulls. Subsequently, iron tanks were used. The forerunner of the modern all steel tanker was built in the late 1880's for the ocean movement of petroleum.

The modern tank truck had to await the develop-

Typical pumping unit

ment of the motor car, but its predecessor, the horse-drawn wagon fitted with a tank, played an important part in the early marketing of petroleum products. These tank wagons, of course, were a later development than the wagons previously mentioned, which had been used to move crude oil from wells to railheads in wooden barrels.

The story of progress in petroleum transportation from the early beginnings is a story of technological development. The oil industry today employs the same five basic transportation media, namely, pipelines, tankers, inland waterway barges, tank trucks and railroad tank cars. While these various forms of transportation may be partially in competition with each other, in practice, they actually supplement one another. Thus, it is typical for more than one media to be used to provide the most economical transportation for crude oil from well to refinery and for petroleum products from refinery to consumer. For example, a typical movement of crude may utilize two or four of the various transportation media such as pipelines from the Texas oil fields to the Gulf Coast, tankers from the Gulf Coast to East Coast refineries, pipelines from East Coast refineries to large cities, and tank trucks for distribution to bulk terminals and to service stations.

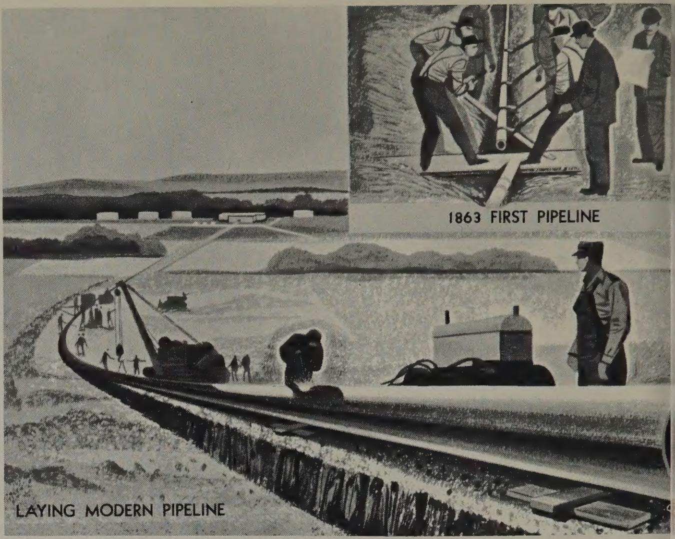
Pipelines—There are approximately 200,000 miles of oil pipelines in the United States as compared to approximately 250,000 miles of main line railroad track. The economy of pipelines makes them a major means of petroleum transportation.

Crude Oil Lines—A crude oil pipeline system delivers crude from the well to the refinery or to terminals in two basic steps: (1) gathering lines from producers' tanks; and (2) main line movement.

Because of the large flow required to maintain capacity throughput on the main line, many gathering systems are required to feed one main line. The gathering system collects oil from tank batteries in an oil field or area, and brings it to a terminal to be fed into the main or trunk line.

Tankers—Flow of crude and products between terminals separated by miles of water is accomplished by tankers. Giant tankers—some holding up to a million barrels—carry crude from producing fields in the Middle East, Africa and South America to refineries in the United States, Europe and the Far East. Other tankers ply our coastal waters, moving thousands of barrels from one terminal to another.

Only a tanker flying the U.S. flag is permitted to operate coastwise between U.S. ports. Tankers carrying foreign flags can bring products to this country from foreign producing areas.



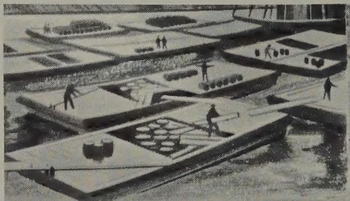
1863 FIRST PIPELINE

LAYING MODERN PIPELINE

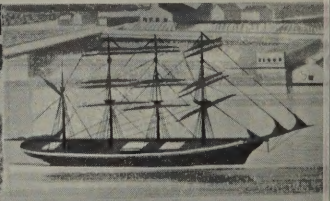
The advantage of the tanker lies in its ability to carry large volumes over many miles of water at low costs.

Barges—Where small volume, short distance, and shallow water become problems, barges take over. Principal crude movements are from offshore producing wells to coastal terminals, and from terminals to refineries. Major product movements are from primary to secondary terminals. There are two types of barges; self-propelled and towed. Barges are primarily used on inland waterways, rivers and lakes. Their capacities range as high as 33,000 barrels.

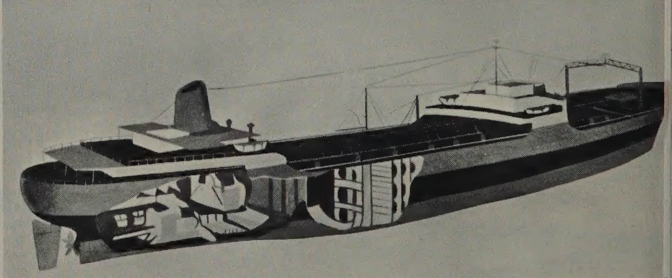
Railroads—Tank cars carrying from 6,000 to 16,000 gallons move product from refinery to terminals.



1860 RIVER BARGES



1885 OCEAN GOING OIL SHIP



CROSS-SECTION OF A MODERN TANK SHIP

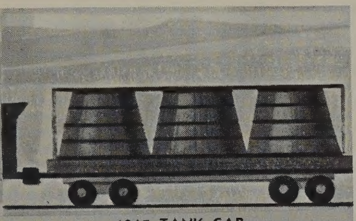
Secondary movement also brings product directly to consumers having sidings and facilities to receive product.

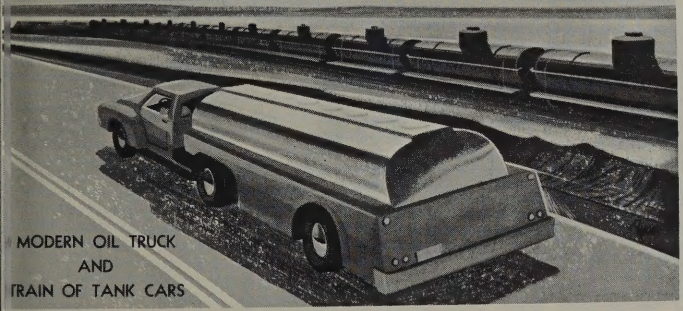
Limited by both size and the restriction of existing rail routes, tank car transportation is declining in importance, and even now accounts for only a small fraction of all petroleum movements.

Motor Transport—The final link in the transportation network is the truck. Because of their ability to maneuver through crowded city streets, and over winding country roads, trucks are continually increasing their importance as a member of the transportation team.

Many trucks today hold as much as some tank cars. Their primary function is to deliver products from terminals to local consuming areas.

1865 OIL DRAY


1865 TANK CAR


MODERN OIL TRUCK AND TRAIN OF TANK CARS

Refining

For several years prior to Drake's discovery of oil, illumination was provided in this country by lamps burning coal oil manufactured, as the name implies, from coal. This fluid was quite expensive and sold in New York City for about one dollar per gallon. Between 1850 and 1859 over fifty companies had set up refineries in the United States for the purpose of manufacturing this coal oil, using a process perfected by an Englishman named James Young. Young had also experimented with crude petroleum and had discovered that a good grade of illuminating oil could be made from it, but he had turned his attention to coal because of the limited supply of crude oil available to him.

In the early 1850's a Pennsylvanian by the name of Samuel W. Kier began the purchase of small quantities of crude oil reclaimed from creeks and wells in the Allegheny, Pennsylvania, area which he sold around the country as a cure-all for all types of muscular aches and pains. In 1855 Kier submitted samples of the Pennsylvania crude to a chemist, who reported that it contained elements from which an illuminating oil and lubrication oil could be processed. Upon receiving this report, Kier constructed a small refinery in Pittsburgh, capable of processing about five barrels of crude oil per day. From the processing, the product carbon oil was obtained which was sold in competition with coal oil.

After Drake's discovery, refineries were constructed rapidly in the Oil Creek region of Pennsylvania in order to keep pace with the rapidly increasing oil production resulting from the drilling of additional wells in the area. The first refineries were operated mainly for the purpose of producing or distilling carbon oil, or kerosene, as it had come to be called. In the process of distillation, a quantity of liquid lighter and more volatile than kerosene was produced. This product, gasoline, now the most important commercial product of crude oil, was thought at that time to be worthless. The gasoline, as well as the heavy residue left after the kerosene was recovered, was either thrown away or burned. Between 1874 and 1889, the residue from the production of kerosene was used as a fuel. Certain salves and medicines were also manufactured from crude oil, but as refining methods were improved the quality of the product also improved.

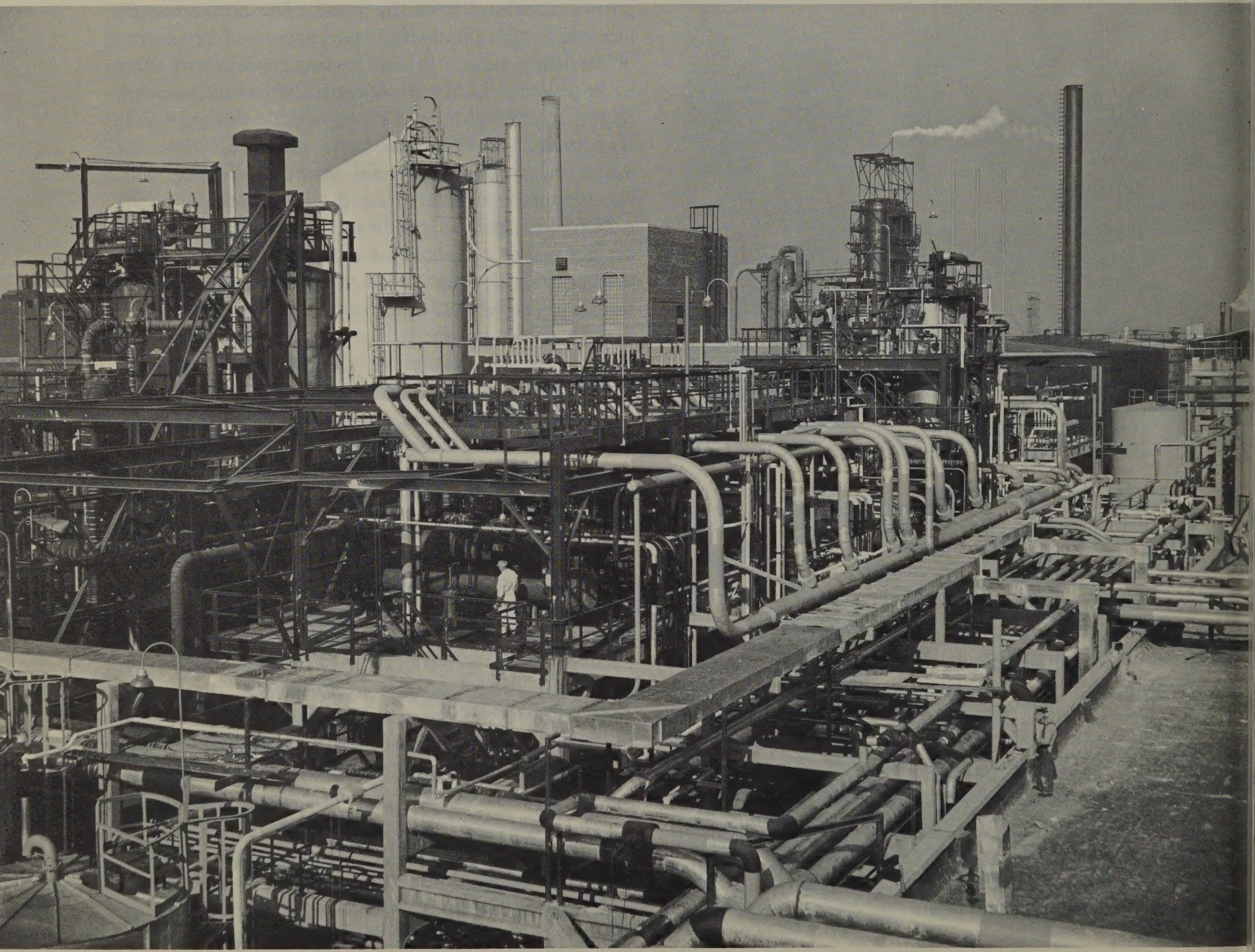
At the turn of the century, the automobile came into the picture and was conveniently preceded by extensive discoveries of additional oil fields. The oil producing and refining industry then took on greater significance due to this broadening of the market for gasoline and lubricants. As the demand for motor fuels and lubricants increased with expansion of the automobile industry, refining methods and techniques improved.

The term *distillation*, as used in the refining industry, means the separation of different components by heating to cause vapors to be driven off and then condensing and recovering the separated liquid. In a simple distillation of pure water, only one vapor (steam) is formed, and this is formed at 212° F. which is the boiling point of water at sea level. Petroleum, however, is made up of many different liquids, each of which has a different boiling point. The low boiling point fractions obtained by distilling crude oil will, when condensed, form such commercial products as solvents and gasoline. Other fractions having relatively higher boiling points will condense to form products such as kerosene, heating oil and diesel fuel. Lubricating oil and heavy fuel oil fractions have a still higher boiling range.

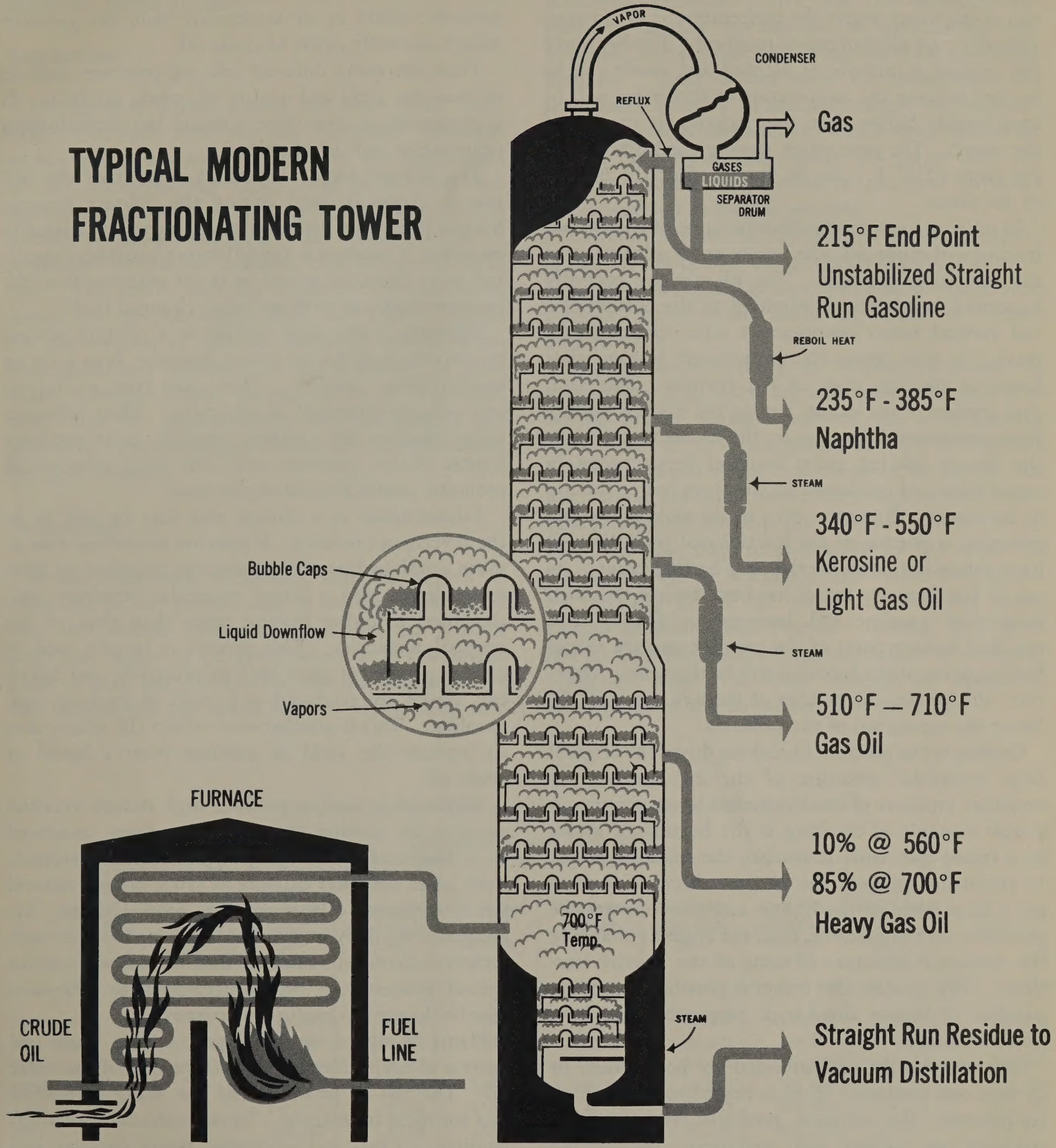
The methods of distilling oil originally were very simple. The charge of crude oil was pumped into a cylindrically shaped vessel which was heated by means of a furnace. As the temperature of the crude oil was gradually increased, the lower boiling fractions were vaporized first, then condensed or liquified by cooling. Following in succession the less volatile or heavier fractions were distilled, and this process was continued until all the desired distillate was removed. There was always a great amount of overlapping of the various products in one another. For example, gasoline contained some kerosene, and kerosene contained some gasoline. In order to separate these various products more accurately, the modern refinery employs a so-called *fractionating tower.*

The fractionating tower works upon the principle that if two or more products having different boiling points are distilled, the one having the lowest boiling point will come off at the top of the tower where the temperature is the lowest, while the product having the highest boiling point will remain near the bottom of the tower where the temperature is highest. For

An Oil Refinery—Note Complexity and Intricacy of Equipment



TYPICAL MODERN FRACTIONATING TOWER



example, if a mixture of alcohol, which has a boiling point of 148° F., and water, with a boiling point of 212° F., is distilled in a fractionating tower, the vapors will pass up the tower to the top. From the top of the tower where the temperature is the lowest, virtually pure alcohol can be removed. Farther down the column a mixture of alcohol and water can be trapped because the temperature at this point will be considerably higher than that existing at the top of the tower. The pure water, having the highest boiling point (212° F.) can be drawn off at the bottom of the tower.

In order to have an efficient separation of the various fractions of crude oil, the refiner takes advantage of the foregoing principle. The oil already partially vaporized in a heater is admitted to the bottom of a tall vertical tower containing a series of horizontal trays. In this tower the temperature is somewhat lower at the top than at the bottom. Therefore, that portion of the vapors having the highest boiling point condenses or liquifies on the lowest trays, while the lowest boiling point fraction keeps rising in vapor form and condenses on the trays nearer the top of the tower. However, even in the most up-to-date refineries, a portion of the fractionated products will have somewhat of an overlapping boiling point. As yet no fractionating tower has been devised that will fractionate gasoline and kerosene so sharply that the final boiling point of the gasoline and the initial boiling point of the kerosene will be the same. However, the greater the number of trays in a tower, the better the separation of the products.

Cracking is the process of breaking down the original large molecular structure of the oil into various resultant products of smaller molecular structure. A simple example of cracking is the heating of grease in a frying pan until it reaches the smoking point. In petroleum refining, the purpose of cracking is to get a large yield of the lighter and more marketable products, such as gasoline, from the crude by changing the molecular structure of some of the heavier fractions. This process also makes it possible to produce gasoline of higher anti-knock properties from low-grade materials.

Cracking can be accomplished by heat alone, or by heat and pressure. If oil is heated to a very high temperature, the ultimate products resulting from cracking are carbon and hydrogen. But if the temperature is controlled to suit the nature of the product the refiner desires to produce, then for each particular oil a maximum yield of gasoline may be obtained. By this method modern refiners are able to increase the yield of gasoline per barrel of crude oil from 25 percent to around 60 percent. Not only is the yield of gasoline increased by cracking, but the quality of the product is improved. Cracked gasoline has a high octane number and, therefore, performs better in an automobile than the gasoline which naturally exists in crude oil.

There are many different refining processes used to increase the yield and quality of certain products. It is impossible to cover these in detail, but the following information will be of value.

The *catalytic process* derives its name from the fact that a chemical, used during the refining process, hastens the action desired in that process. Chemically speaking, a catalyst is any substance capable of speeding up a chemical action without entering into the reaction itself, or without being changed itself.

Reforming is the term applied to a refining process to convert naphtha, or heavy gasoline, into a better quality motor gasoline. There exist both a catalytic and a thermal method of reforming. Most refineries today employ the catalytic method as it produces higher octane gasoline and also some commercial aromatic chemicals such as benzene.

Polymerization in a general way may be said to be the reverse of cracking. It consists of linking two or more small hydrocarbon molecules together to form molecules having a larger molecular structure and, therefore, a higher boiling point than that of the original molecules. This process is largely used to change petroleum gases such as propylene and butylene, which are produced as a result of cracking, into gasoline. This is another way which the refiner uses to increase the yield of gasoline from a barrel of crude oil.

Alkylation is used to produce high octane aviation gasoline by uniting the petroleum gases, produced as a result of cracking (propylene and butylene), with gases naturally existing in crude oil and natural gas (isobutane). Isomerization, aromatization, hydrogenation, dehydrogenation, and many other such technical chemical names are used to indicate various special processes by which hydrocarbon structures may be changed to produce improved fuels.

Plants equipped to fully process the crude oil recover in usable form almost 100 percent of the crude oil. The list of products and the many diversified uses for them is amazing. To mention some: aviation gasoline, jet fuel and lubricants, motor gasoline and lubricants, naphtha solvents used to produce varnish and paint, kerosene, light industrial and home heating fuels, diesel fuels, candy maker's oil, fruit packer's oil, salves, creams, medicinal ointments, cosmetics, laundry wax, sealing wax, floor oil, heavy lubricating greases, asphalt for paving roads and streets, roofing material, anti-freeze compounds for automobiles and airplanes and a compound from which synthetic rubber is made.

Employment

Employment figures during the years 1950, 1955, 1959, 1960 and 1961 for the functional divisions of the petroleum and gas industry are represented in the accompanying table. The table does not include manpower figures in retail outlets, nor the number of persons engaged in the transportation of petroleum by barges, tankers, tank trucks or tank cars. The yearly industry totals are representative except for the years 1959, 1960, and 1961. Figures for the number of persons employed in petroleum bulk plants and terminals are not available for these years. Despite these omissions, it is estimated that there are approximately 800,000 persons employed in these functional divisions of the petroleum and gas industry.

Conservation

It has long been recognized that our supply of crude oil at the present rate of consumption might one day become exhausted. No one can predict with any degree of certainty when or if this might come to pass, but it is known that our existing fields will not supply our needs forever. How long new deposits will continue to be found no one knows, nor is there any presently known method by which such knowledge could be gained. The demand for petroleum increases yearly, due to industrial expansion, increase in the use of automobiles and airplanes, and the new uses being found for petroleum products. These factors serve to demonstrate the importance to us of an adequate supply of crude oil. It is a precious commodity, which once exhausted cannot be replaced and makes us realize that the greatest possible care should be exercised to make our supply last as long as possible.

There are within the United States large partially or fully developed oil and gas fields which, if allowed to produce as rapidly as they are capable, would soon produce more than could be used or stored economically.

Regulations controlling the drilling and producing operations of oil wells are maintained by each producing State. Though some of the oil-producing States seem to have recognized as early as the late 1890's the necessity for conserving or saving oil and gas, it was not until about 1915 that the first State law was passed to stop the excessive production of oil. The first State to pass a law of this type was Oklahoma, but such measures have since been passed by virtually all of the major oil-producing States except California and Illinois. Instead of a State law in California, the oil operators have a system of voluntary control in effect through an agreement between all of the oil producers of the State.

Petroleum and Gas Industry Manpower Statistics 1950–1961

[Number of persons employed]

Year	Crude petroleum & natural gas (131)	Natural gas liquids (132)	Oil & Gas field services (138)	Petroleum refining (291)	Petroleum pipe lines (461)	Gas companies and systems (492)	Petroleum bulk plants & terminals (512) [1] (5092) [2]	Total
1950	141, 405	10, 979	85, 150	190, 231	26, 868	119, 512	170, 097	744, 242
1955	162, 788	14, 070	119, 635	200, 910	26, 142	139, 827	195, 929	859, 301
1958	172, 596	9, 237	131, 366	192, 553	25, 161	150, 555	[3] 134, 612	816, 080
1959	166, 117	9, 198	138, 313	183, 577	24, 091	152, 288	[4] N.A.	673, 584
1960	161, 127	8, 862	129, 579	176, 556	22, 995	152, 981	[4] N.A.	652, 100
1961	155, 667	8, 008	130, 418	169, 204	22, 123	153, 216	[4] N.A.	638, 636

[1] 512 represents the industrial classification of petroleum bulk plants prior to 1957.

[2] 5092 represents the industrial classification subsequent to 1957.

[3] 134,612 represents figure as taken from 1958 Census of Business, U.S.D.C. & Bureau of Census-Petroleum Bulk Plants and Terminals.

[4] Not available.

Source: Bureau of Employment Security, U.S.D.L.

The regulations established by the various States for the purpose of keeping production in balance with the demand are generally termed "proration regulations." Under the provisions of such regulations a commission or department of the State government fixes the amount that each individual oil or gas well may produce. Also, these regulations usually stipulate the number of wells that may be drilled on acreage of a certain size, and what distance the well must be located from adjacent property lines.

Before the passage of State proration laws, the producer who was willing to produce his oil at a slow rate could be damaged by doing so because there were usually other producers with wells producing from the same pool who were of a selfish nature and who, by flowing their wells to an excessive rate, could seriously injure the formation from which the oil was coming. Damage to the producing formation could be done by dissipating the energy of the reservoir and pulling in edge or bottom water, at the same time draining the oil from under the land of their more farsighted neighbor.

The National Industrial Recovery Act enacted in 1933 authorized the President of the United States to prohibit the shipment in interstate or foreign commerce of petroleum or products of petroleum which had been produced, transported or withdrawn from stock in excess of amounts permitted by State laws and regulations. The enforcement of this act was of particular benefit in East Texas during 1933 and 1934 in helping to solve a situation that had been created as a result of flagrant violations of State proration orders. In January of 1935 the Supreme Court of the United States declared the National Recovery Act unconstitutional; however, in February of the same year the Congress passed an Act, known as the Connally Act, containing essentially the same provisions but with the unconstitutional objection removed. The constitutionality of this Act has been upheld in several cases.

The necessity for petroleum conservation is better realized by the industry and the general public with each passing year. The formation of the Interstate Oil Compact Commission represents one of the most significant joint State efforts ever undertaken in the interest of oil and gas conservation. Through this media, 30 of the 31 oil producing States are striving together to solve the very complex conservation problems that have confronted the oil industry since its inception.

Role of the Department of the Interior in Relation to Oil and Gas

Helping to assure the Nation of an adequate supply of petroleum and natural gas for the present and the future, under peacetime and defense mobilization conditions, is a responsibility of the Federal Government through the medium of its Department of the Interior, which in turn delegates this responsibility to the Office of Oil and Gas, Bureau of Land Management, Bureau of Mines and Geological Survey.

Office of Oil and Gas

The Office of Oil and Gas provides staff advice and technical assistance to the Secretary of the Interior, the Assistant Secretary for Mineral Resources and the Secretariat in the development, coordination and management of Federal programs, both domestic and foreign, concerned with current and future petroleum and gas resources. In performing its functions the Office of Oil and Gas is the focal point of information for the Congress, government agencies (Federal and State) and the public. It serves as a vital channel of communication between the Federal Government and the Interstate Oil Compact Commission, State oil and gas regulatory bodies and the petroleum and gas industries.

Other activities of the Office of Oil and Gas include the following functions:

1. Provides the leadership in obtaining the unification of oil and gas activities of the various Federal Agencies and the industry itself, and enlists their cooperation to assure adequate supply, distribution and utilization of petroleum and gas resources with the facilities to meet civilian, industrial and military requirements in times of peace, international tension or any national emergency that might occur.
2. Under the direction of the Assistant Secretary for Mineral Resources, the Office of Oil and Gas and the Petroleum Security Subcommittee assist in the administration of the Voluntary Agreement relating to Foreign Petroleum Supply, continually evaluating world-wide petroleum operations and resources available to support assumptions outlined by the Department of Defense.

UNITED STATES DEPARTMENT OF THE INTERIOR
OFFICE OF OIL AND GAS

DIRECTOR

Exercises general direction over all activities of the Office of Oil and Gas

INTERNATIONAL ORGANIZATIONS STAFF

Provides advice and assistance regarding petroleum and gas matters to United States delegations to international economic and defense organizations, including the North Atlantic Treaty Organization, the Organization for Economic Cooperation and Development, United Nations Regional Economic Organizations; and participates in the activities of their Committees and Working Groups.

ADMINISTRATIVE SERVICES

Provides services for administrative activities, including fiscal, personnel, management of property and equipment, and physical security.

ASSISTANT DIRECTOR PROGRAMMING

Has responsibility for development of worldwide supply-demand programs of petroleum and gas under peacetime and emergency conditions; for development of emergency preparedness plans and programs; for activities of industry advisory groups under the Voluntary Agreement Relating to Foreign Petroleum Supply; and for coordination of programs involving international organizations.

Jerome J. O'Brien, Director
John Ricca, Assistant Director (Programming)
Frederick S. Lott, Assistant Director (Operations)
Mac Goodman, International Organizations Staff
Russell W. Slight, Administrative Services
Harold J. Barton, Programming (Domestic)
C. Marvin Case, Programming (Foreign)
Paul L. Hopper, Emergency Planning
Charles A. Nichols, Jr., Voluntary Agreement Advisory Committees
Earl G. Ellerbrake, Transportation and Storage
Charles S. Joanedis, Refining
Forrest F. Irantham, Gas
Joseph J. Simmons, III, Production (Domestic)
Charles L. Moore, Production (Foreign)

ASSISTANT DIRECTOR OPERATIONS

Has responsibility for development of operating plans and programs to assure adequate productive capacity to locate, produce, refine, transport, store and distribute crude oil, petroleum products, natural and manufactured gas to meet essential civilian, industrial and military requirements of the free world under peacetime and emergency conditions; and for activities pertaining to the operation of the National Petroleum Council.

PROGRAMMING DOMESTIC

Prepares analyses and forecasts of petroleum and gas supply and demand under normal and various emergency conditions as a basis for plans to meet essential requirements.

PROGRAMMING FOREIGN

Prepares worldwide analyses and forecasts of petroleum and gas supply and demand, by countries and by totals, and related international flow of crude and products, under normal and various emergency conditions as a basis for military and civilian plans to meet essential requirements.

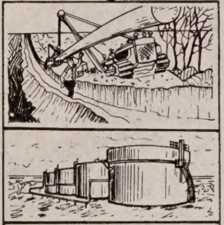
EMERGENCY PLANNING

Develops emergency plans and programs, including organization of Emergency Petroleum and Gas Administration and its Executive Reserve; provides guidance to oil and gas industries in survival planning, and state and local governments in development and testing of emergency plans.

8 MOBILIZATION REGIONS

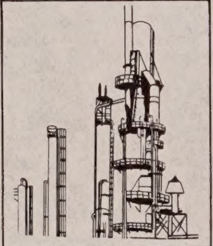
VOLUNTARY AGREEMENT ADVISORY COMMITTEES

Coordinates industry advisory committees authorized by the Voluntary Agreement relating to Foreign Petroleum Supply, including the Foreign Petroleum Supply Committee and the Petroleum Security Subcommittee. Develops information on economic and political trends affecting foreign petroleum operations.



TRANSPORTATION AND STORAGE

Provides technical advice on crude oil and petroleum products transportation by pipelines, tankers, etc; develops plans and studies of worldwide transportation and storage capabilities to meet essential requirements under peacetime and emergency conditions.

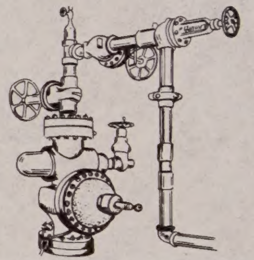


REFINING

Provides technical advice on petroleum processing; develops studies and prepares reports reflecting worldwide refinery capabilities for use in plans and programs under peacetime and emergency conditions.

GAS

Provides technical advice on the transmission, storage, and distribution of natural and manufactured gas to meet domestic and foreign peacetime and emergency requirements.



PRODUCTION DOMESTIC

Provides technical information on U. S. actual production and proved reserves, determines potential capacity to produce crude oil and natural gas to meet current and emergency requirements.

PRODUCTION FOREIGN

Provides technical information on foreign production and crude reserves, determines potential capacity to produce crude oil and natural gas to meet current and emergency requirements.

July 1963

3. Provides advice and assistance for United States representatives and delegations to varied international organization meetings such as NATO's Petroleum Planning Committee, the regional economic organizations and Economic and Social Commission of the United Nations, and the World Petroleum Congress.

4. Continually plans, develops and implements programs for petroleum and gas defense mobilization in the United States, a part of which has been the establishment of a Petroleum and Gas National Defense Executive Reserve Unit, consisting of selected industry and Federal personnel whose services will be available during any national emergency.

Guidance and assistance is being given to state and oil industry personnel for their civil defense planning by the national office and our regional Oil and Gas Mobilization representatives in the eight Office of Emergency Planning regional areas.

Bureau of Land Management

The Bureau of Land Management, as the office of record and custodian of the Federal Lands, is responsible for many of the managerial and quasilegal phases of the administration of Federal laws governing the insurance and control of Federal oil and gas leases. Large areas of these Federal Lands are still relatively unexplored and development of the off-shore submerged lands of the Continental Shelf is well underway. Commercial development of oil shale, much of which is on public lands, will make still greater contributions to our future liquid fuels supply.

The Federal Government occupies much the same position as any private land owner in the United States in that it owns land and leases it to individuals and private companies for oil and gas exploration and development. It does not engage in drilling for oil or gas on its own account except in a few specific rare instances, such as on the Naval Petroleum Reserves, and by the Bureau of Mines in fields purchased or leased for production of helium-bearing natural gas. It does not subsidize or provide financial assistance to individuals or private industry for drilling for oil or gas.

The Federal Government, with jurisdiction over 716 million acres of Public Domain, including federally-owned and controlled lands in the United States and over 361 million acres in Alaska, is the largest single land owner. As such, and in the public interest, pursuant to public laws, it must and does exercise considerable supervisory control over oil and gas operations conducted upon its lands. Where oil and gas is produced on federally controlled lands, the spacing of wells, fixing of allowable production from wells (proration), and other conservation regulations are generally administered by State laws or State authorities.

As of December 31, 1962, there were in the United States and Alaska 96,280,054 acres of Federally controlled land under oil and gas lease in 143,054 active oil and gas leases. In addition, there were 846 oil and gas leases in the outer Continental Shelf off Louisiana and Texas covering 3,685,487 acres.

Administration of authority over these federal lands with respect to oil and gas leasing, exploration, development and production is vested in the United States Department of the Interior, Washington, D.C. The responsibility in administration is delegated to the following Interior offices:

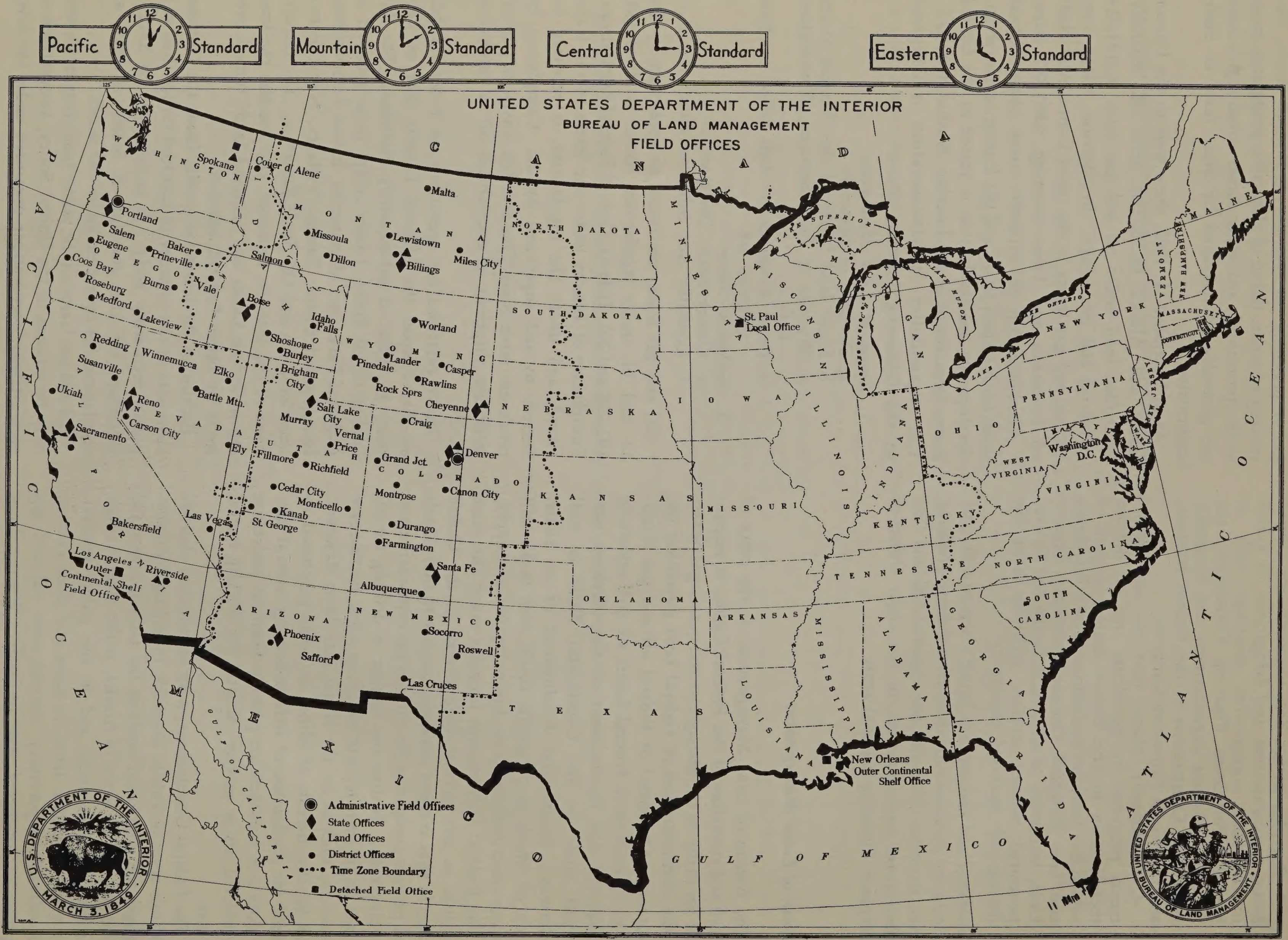
1. *Bureau of Land Management*
    a. Division of Minerals
    b. Local land offices in the Western States
    c. Division of Field Services, Washington, D.C.
    d. Outer Continental Shelf office in New Orleans, La.
2. *Geological Survey*
    a. Conservation Division
    b. Connally Act Administration

Oil and gas leases are issued to applicants by 1b, 1c, and 1d, under regulations issued as Parts 191, 192, 200 and 201, Title 43, Code of Federal Regulations. Compliance of Lessees under the terms of the leases issued, and under the regulations, is reported by Lessees to and supervised by 2a. Compliance by producers with State Conservation Laws to prevent interstate shipment of contraband oil is supervised by 2b.

The regulations for operations on Federal Lands are based upon the Mineral Leasing Act of February 25, 1920, as subsequently amended. The Act applies to all Public Lands except those situated in National Parks and Monuments, Indian Reservations, Incorporated Cities, Towns, Villages, Naval Petroleum Reserves and Oil Shale Reserves. The Department of the Interior, however, also handles the leasing of Indian Lands and acquired lands turned over to it by other Federal agencies.

Because of the leasing of public lands the Government acts in the capacity of landlord rather than as a purely regulatory body. It is necessary to have a procedure for the granting of leases as well as regulations for operation under the leases.

Oil and gas leases on the public lands may be secured only by citizens of the United States, associations of such citizens, corporations organized under the laws

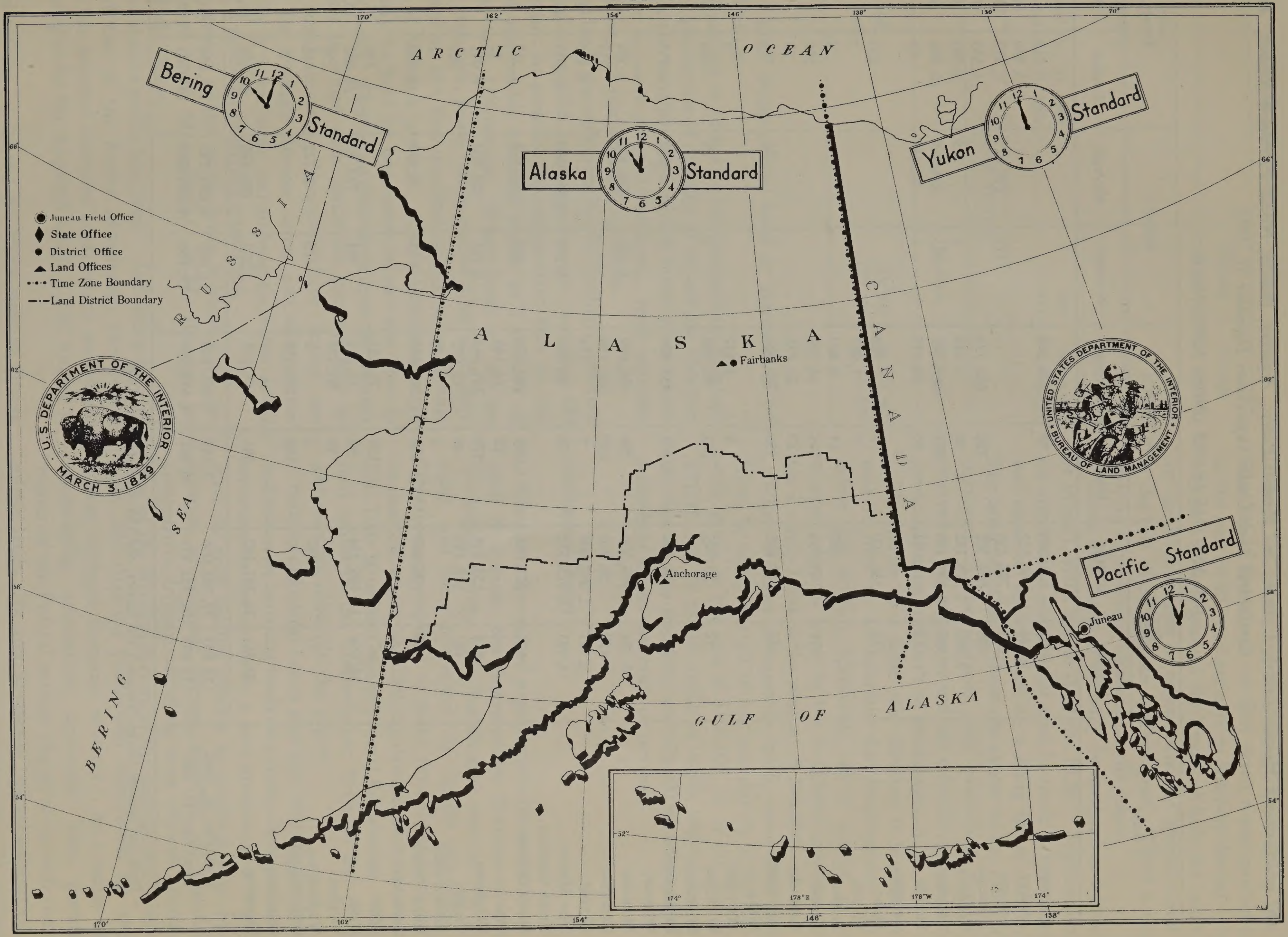


UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FIELD OFFICES

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

FIELD OFFICES



Oil and Gas and Mineral Leases, Licenses, and Permits Public, Acquired, Indian, Naval Petroleum Reserve, and Outer Continental Shelf Under Supervision December 31, 1962

OIL AND GAS LEASES UNDER SUPERVISION

State	Public		Acquired		Indian [a]		Total	
	Number	Acreage	Number	Acreage	Number	Acreage	Number	Acreage
Alabama	82	21, 384	36	52, 989			118	74, 373
Alaska	9, 846	19, 550, 312					9, 846	19, 550, 312
Arizona	2, 293	1, 786, 196			119	258, 415	2, 412	2, 044, 611
Arkansas	626	609, 391	729	620, 129			1, 355	1, 229, 520
California	3, 680	1, 575, 182	58	9, 449	2	269	3, 740	1, 584, 900
Colorado	11, 998	8, 595, 119	382	466, 320	225	354, 606	12, 605	9, 416, 045
Florida	19	2, 082	60	99, 235	4	10, 240	83	111, 557
Georgia								
Idaho	228	332, 100	2	280			230	332, 380
Illinois			7	1, 917			7	1, 917
Indiana	1	320	13	8, 807			14	9, 127
Kansas	171	47, 953	195	44, 399			366	92, 352
Kentucky			20	20, 872			20	20, 872
Louisiana	427	52, 893	356	288, 631	1	262	784	341, 786
Maine								
Maryland			8	8, 347			8	8, 347
Michigan	52	33, 325	143	66, 689	1	19	196	100, 033
Minnesota								
Mississippi	245	24, 390	1, 705	857, 404	5	653	1, 955	882, 447
Missouri								
Montana	6, 851	5, 263, 590	794	609, 649	1, 949	476, 399	9, 594	6, 349, 638
Nebraska	198	55, 310	139	108, 158			337	163, 468
Nevada	3, 365	1, 007, 606	5	714			3, 370	1, 008, 320
New Mexico	14, 593	9, 813, 372	70	33, 262	1, 370	1, 565, 600	16, 033	11, 412, 234
North Carolina								
North Dakota	652	271, 061	1, 056	760, 870	549	53, 508	2, 257	1, 085, 439
Ohio			22	16, 148			22	16, 148
Oklahoma	814	133, 554	376	245, 944	5, 741	522, 804	6, 931	902, 302
Oregon	162	128, 193	40	11, 092			202	139, 285
Pennsylvania			1	192			1	192
South Dakota	888	794, 807	130	113, 985	12	7, 418	1, 030	916, 210
Tennessee								
Texas			196	78, 284			196	78, 284
Utah	28, 054	15, 798, 284	32	41, 235	794	723, 726	28, 880	16, 563, 245
Virginia			59	80, 176			59	80, 176
Washington	27	9, 380	2	2	26	1, 722	55	11, 104
West Virginia			166	205, 538			166	205, 538
Wisconsin								
Wyoming	39, 531	21, 287, 252	381	151, 142	270	109, 498	40, 182	21, 547, 892
Total Dec. 31, 1962	124, 803	87, 193, 056	7, 183	5, 001, 859	11, 068	4, 085, 139	143, 054	96, 280, 054
Total Dec. 31, 1961	133, 805	101, 382, 419	6, 592	4, 659, 350	11, 366	4, 205, 518	151, 763	110, 247, 287

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[a] Does not include Osage Nation 3,510 Leases, 618,136 Acres June 30, 1962.

OUTER CONTINENTAL SHELF

	Number	Acreage
Off California		
Off Florida	11	63, 360
Off Louisiana	786	3, 439, 247
Off Texas	49	182, 880
Total Dec. 31, 1962	846	3, 685, 487
Total Dec. 31, 1961	457	1, 924, 753

GRAND TOTAL

	Number	Acreage
Dec. 31, 1962	143, 900	99, 965, 541
Dec. 31, 1961	152, 220	112, 172, 040

of the United States or any State or Territory or by municipalities.

The granting of a lease for the prospecting, development or production of deposits of oil and gas does not preclude the issuance of permits or leases on the same land for deposits of other minerals, with suitable stipulations for simultaneous operation.

When lands are within the known geologic structure of a producing field, leases in units not exceeding 640 acres must be awarded by competitive bids to the highest responsible qualified bidder at a royalty of not less than 12½ percent. Where lands are not on such a structure, leases not to exceed 2,560 acres may be issued to the first qualified offerer at an annual rental of 50 cents per acre. The maximum acreage that may be held by one lessee in any one State is 246,080 acres. There is no limitation upon the number of States in which such maximum interests may be held simultaneously. Noncompetitive leases are issued for a single 10-year term, and competitive leases for a 5-year term, and so long thereafter as oil or gas is produced in paying quantities.

The leasing of the public lands is handled by the Bureau of Land Management (BLM) through its State Field Offices.

Texas is not a public land State. In States primarily located east of the Rocky Mountains, the United States has acquired extensive lands which are subject to leasing under the Acquired Lands Act of August 7, 1947.

Applications for oil and gas leases must be filed in quintuplicate in the appropriate BLM State Office. They must contain an adequate description of the lands to be leased, and must be accompanied by the filing fee of $10.00 and the first year's rental payment at the rate of 50 cents per acre or fraction thereof.

Once a lease is granted the lessee can hold the lands for the 10-year term by payment of the annual rental at the rate of 50 cents an acre per year. There is no drilling requirement imposed on the lessee.

Lands held under leases may be assigned in whole or in part, with approval of the BLM. Application for approval of assignments must be made in triplicate and must be accompanied by a filing fee of $10.00. The assignment must show the extent of the interest conveyed to the assignee, any overriding royalty reserved to the assignor, and any overriding royalties previously reserved, both in percentages only.

The holder of a lease may develop it himself or turn it over to an operator for development, but before any drilling operations can be started it is necessary for the lessee or his designated operator to file a surety bond in the amount of $10,000.

Where a lessee or operator holds more than one lease, he can cover all of his interests by a Nationwide Bond, in the sum of $150,000, or at the rate of $25,000 for all public lands he holds under lease in any one State or territory, and $25,000 for all acquired lands held in any one State or territory.

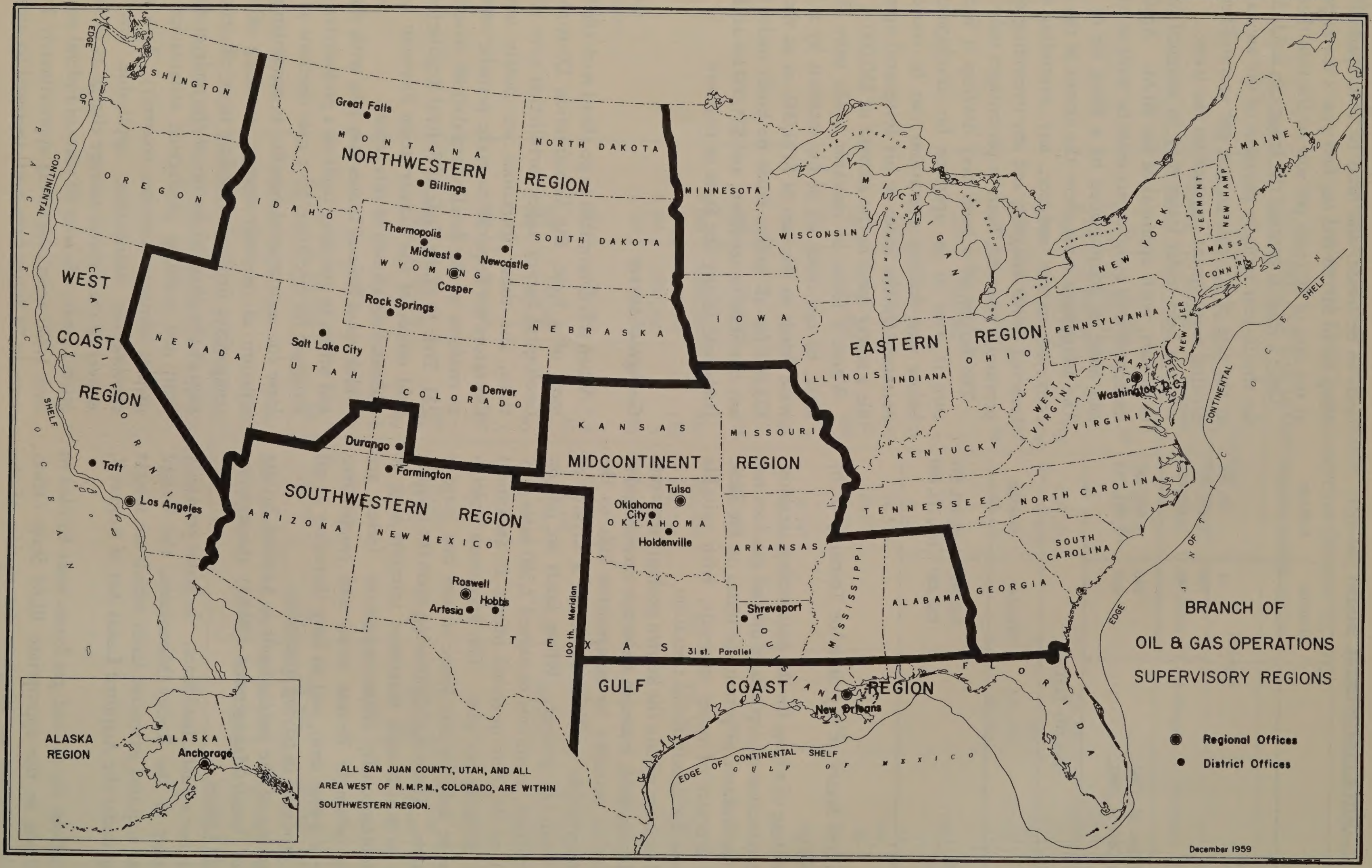
Geological Survey

When it is determined to go ahead with the development of a lease, the Conservation Division of the Geological Survey takes jurisdiction over all operations, and these operations are closely supervised. Operators are required to make periodic reports and to conform to the detailed regulations issued as Part 221, Title 30 of the Code of Federal Regulations. The field offices of the Conservation Division and their addresses are shown in this report.

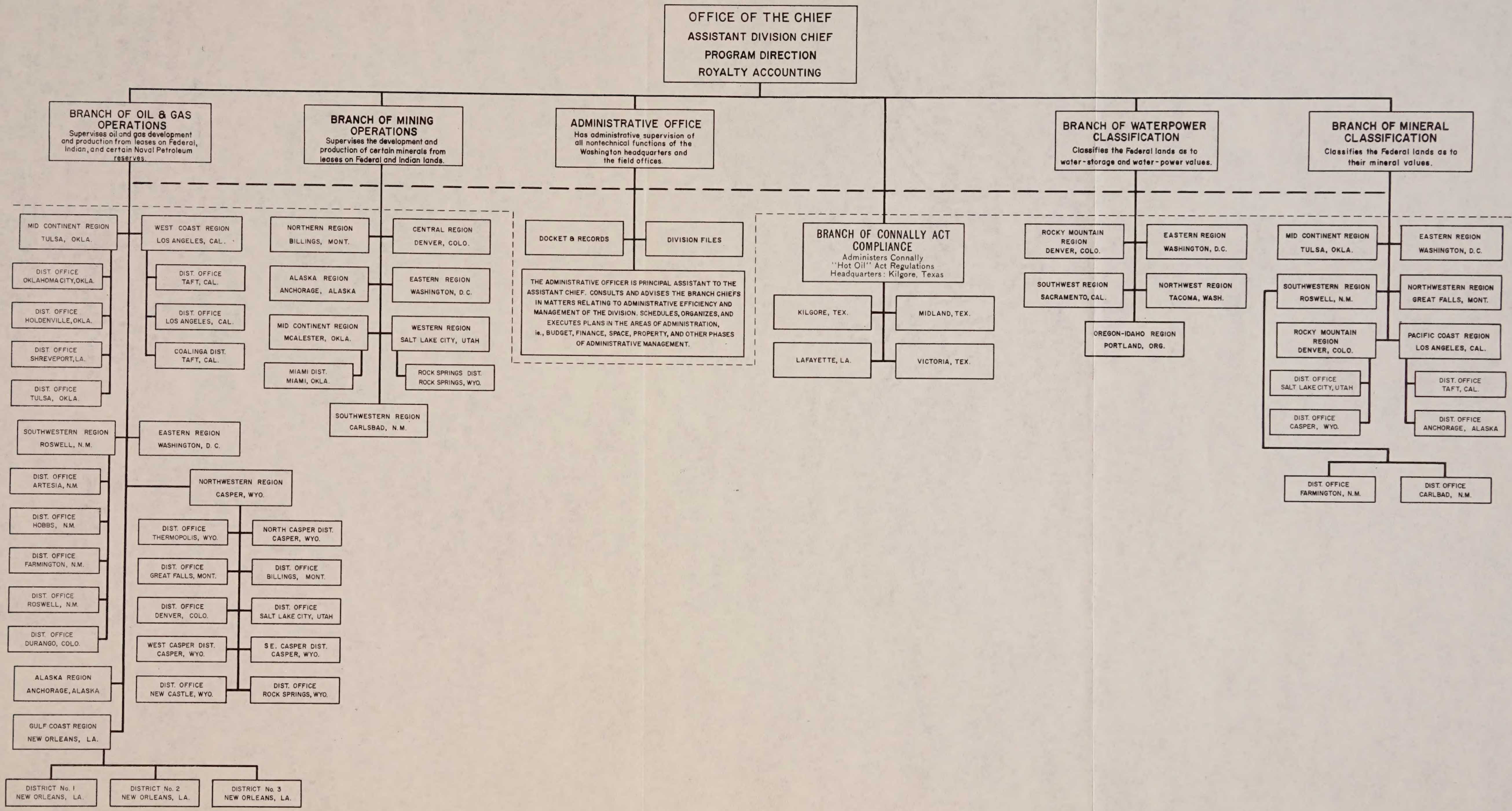
Holders of Federal Leases may join with themselves and others in unitizing lands on a prospective geologic structure for operation by a unit operator as a single lease for such mutual benefits as minimizing of dissipation of reservoir energy, avoiding of wasteful competitive drilling, affording more efficient utilization of the physical factors of the underground reservoir, and enabling production stimulation for the greater ultimate economic recovery. As a means of encouraging unitization, applicable laws permit waiver of the Federal acreage charge as to such committed lands. In over 30 years of Federal unitization, over 1,300 units containing approximately 24 million acres in 23 States have been approved by authority of

GEOLOGICAL SURVEY

CONSERVATION DIVISION



ORGANIZATION OF THE CONSERVATION DIVISION
GEOLOGICAL SURVEY


OFFICE OF THE CHIEF
ASSISTANT DIVISION CHIEF
PROGRAM DIRECTION
ROYALTY ACCOUNTING
BRANCH OF OIL & GAS OPERATIONS
Supervises oil and gas development and production from leases on Federal, Indian, and certain Naval Petroleum reserves.
MID CONTINENT REGION TULSA, OKLA.
DIST. OFFICE OKLAHOMA CITY, OKLA.
DIST. OFFICE HOLDENVILLE, OKLA.
DIST. OFFICE SHREVEPORT, LA.
DIST. OFFICE TULSA, OKLA.
WEST COAST REGION LOS ANGELES, CAL.
DIST. OFFICE TAFT, CAL.
DIST. OFFICE LOS ANGELES, CAL.
COALINGA DIST. TAFT, CAL.
SOUTHWESTERN REGION ROSWELL, N.M.
DIST. OFFICE ARTESIA, N.M.
DIST. OFFICE HOBBS, N.M.
DIST. OFFICE FARMINGTON, N.M.
DIST. OFFICE ROSWELL, N.M.
DIST. OFFICE DURANGO, COLO.
EASTERN REGION WASHINGTON, D. C.
NORTHWESTERN REGION CASPER, WYO.
DIST. OFFICE THERMOPOLIS, WYO.
NORTH CASPER DIST. CASPER, WYO.
DIST. OFFICE GREAT FALLS, MONT.
DIST. OFFICE BILLINGS, MONT.
DIST. OFFICE DENVER, COLO.
DIST. OFFICE SALT LAKE CITY, UTAH
WEST CASPER DIST. CASPER, WYO.
S.E. CASPER DIST. CASPER, WYO.
DIST. OFFICE NEW CASTLE, WYO.
DIST. OFFICE ROCK SPRINGS, WYO.
ALASKA REGION ANCHORAGE, ALASKA
GULF COAST REGION NEW ORLEANS, LA.
DISTRICT No. 1 NEW ORLEANS, LA.
DISTRICT No. 2 NEW ORLEANS, LA.
DISTRICT No. 3 NEW ORLEANS, LA.
BRANCH OF MINING OPERATIONS
Supervises the development and production of certain minerals from leases on Federal and Indian lands.
NORTHERN REGION BILLINGS, MONT.
CENTRAL REGION DENVER, COLO.
ALASKA REGION ANCHORAGE, ALASKA
EASTERN REGION WASHINGTON, D. C.
MID CONTINENT REGION MCALESTER, OKLA.
WESTERN REGION SALT LAKE CITY, UTAH
MIAMI DIST. MIAMI, OKLA.
ROCK SPRINGS DIST. ROCK SPRINGS, WYO.
SOUTHWESTERN REGION CARLSBAD, N.M.
ADMINISTRATIVE OFFICE
Has administrative supervision of all nontechnical functions of the Washington headquarters and the field offices.
DOCKET & RECORDS
DIVISION FILES
BRANCH OF CONNALLY ACT COMPLIANCE
Administers Connally "Hot Oil" Act Regulations
Headquarters: Kilgore, Texas
KILGORE, TEX.
MIDLAND, TEX.
LAFAYETTE, LA.
VICTORIA, TEX.
BRANCH OF WATERPOWER CLASSIFICATION
Classifies the Federal lands as to water-storage and water-power values.
ROCKY MOUNTAIN REGION DENVER, COLO.
EASTERN REGION WASHINGTON, D.C.
SOUTHWEST REGION SACRAMENTO, CAL.
NORTHWEST REGION TACOMA, WASH.
OREGON-IDAHO REGION PORTLAND, ORG.
BRANCH OF MINERAL CLASSIFICATION
Classifies the Federal lands as to their mineral values.
MID CONTINENT REGION TULSA, OKLA.
EASTERN REGION WASHINGTON, D.C.
SOUTHWESTERN REGION ROSWELL, N.M.
NORTHWESTERN REGION GREAT FALLS, MONT.
ROCKY MOUNTAIN REGION DENVER, COLO.
PACIFIC COAST REGION LOS ANGELES, CAL.
DIST. OFFICE SALT LAKE CITY, UTAH
DIST. OFFICE CASPER, WYO.
DIST. OFFICE TAFT, CAL.
DIST. OFFICE ANCHORAGE, ALASKA
DIST. OFFICE FARMINGTON, N.M.
DIST. OFFICE CARLBAD, N.M.

THE ADMINISTRATIVE OFFICER IS PRINCIPAL ASSISTANT TO THE ASSISTANT CHIEF. CONSULTS AND ADVISES THE BRANCH CHIEFS IN MATTERS RELATING TO ADMINISTRATIVE EFFICIENCY AND MANAGEMENT OF THE DIVISION. SCHEDULES, ORGANIZES, AND EXECUTES PLANS IN THE AREAS OF ADMINISTRATION, ie., BUDGET, FINANCE, SPACE, PROPERTY, AND OTHER PHASES OF ADMINISTRATIVE MANAGEMENT.

707-329 O - 63 (Face p. 26)

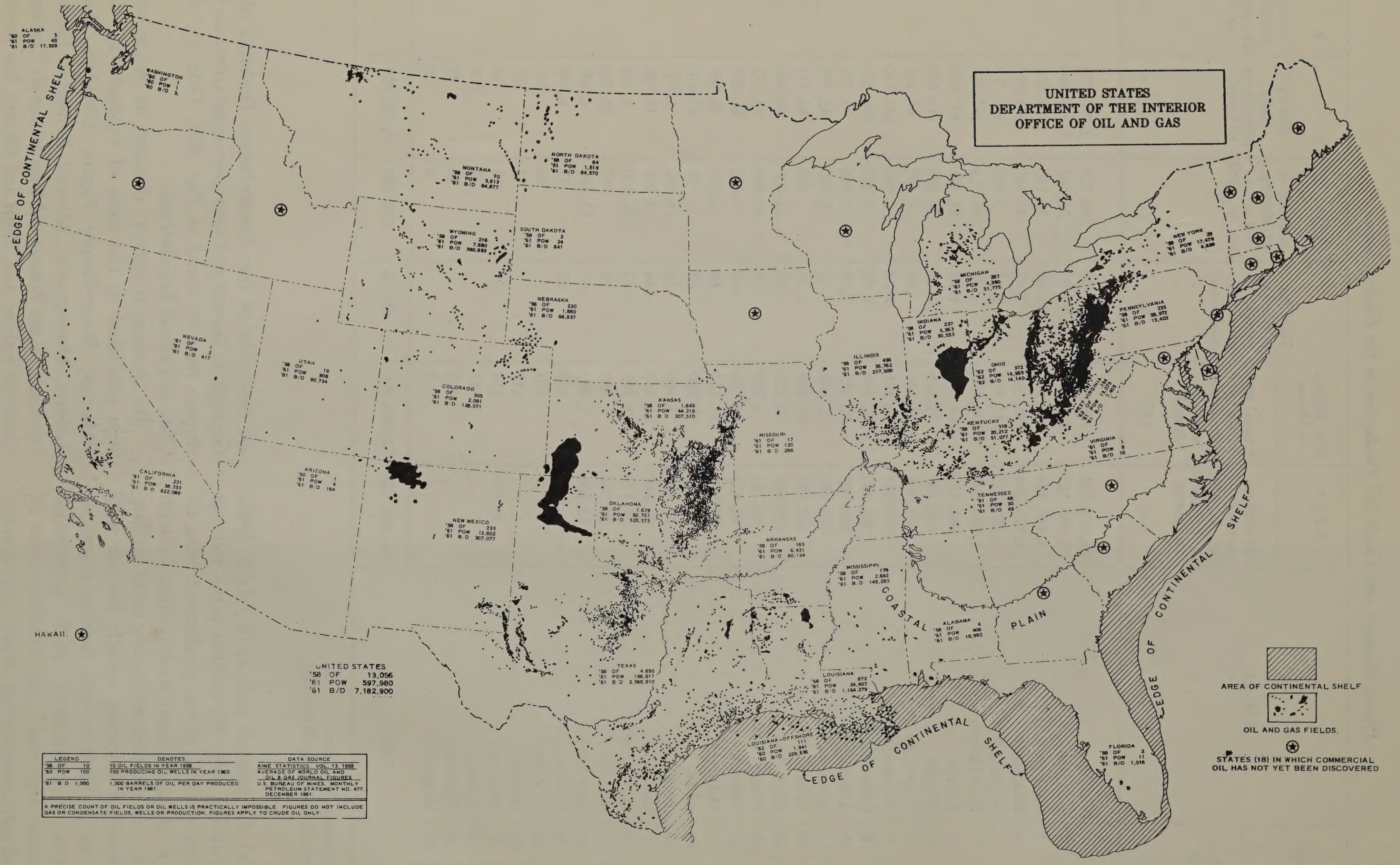
Proved Reserves and Crude Oil Production in the United States

31 States in order of their		States	A.P.I.*	U.S. Bureau of Mines	State production as percent of total U.S. production	Number of producing oil wells Dec. 31, 1962	Average daily production in barrels	Average barrels per day per well in 1962
Reserves	Production		Proved reserves as of Dec. 31, 1962 in thousands of barrels	Annual production for 1962 in thousands of barrels				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	1	Texas	14,648,325	936,508	34.99	193,728	2,565,775	13.2
2	2	Louisiana	5,086,622	483,101	18.05	25,642	1,323,564	51.6
3	3	California	3,648,434	296,572	11.08	39,193	812,526	20.7
4	4	Oklahoma	1,728,268	198,563	7.42	81,545	544,008	6.7
5	5	Wyoming	1,297,023	145,167	5.42	9,400	397,718	42.3
6	7	New Mexico	1,064,590	108,708	4.06	14,233	297,830	20.9
7	6	Kansas	862,410	112,076	4.19	47,561	307,058	6.5
8	8	Illinois	460,160	77,325	2.89	30,196	211,849	7.0
9	14	N. Dakota	403,467	25,164	.94	1,582	68,943	43.6
10	9	Mississippi	388,383	54,471	2.04	2,560	149,236	58.3
11	10	Colorado	388,330	42,460	1.59	1,975	116,329	58.9
12	13	Arkansas	264,795	27,585	1.03	5,844	75,575	12.9
13	11	Montana	248,860	31,648	1.18	3,700	86,707	23.4
14	12	Utah	197,722	30,964	1.16	820	84,833	103.5
15	16	Kentucky	108,626	18,122	.68	19,800	49,649	2.5
16	21	Pennsylvania	96,748	5,225	.20	56,900	14,315	.3
17	15	Nebraska	93,824	24,850	.93	1,855	68,082	36.7
18	17	Michigan	74,996	17,117	.64	4,370	46,896	10.7
19	19	Alaska	....	10,260	.38	52	28,110	540.5
20	22	Ohio	77,321	5,066	.19	14,500	13,880	1.0
21	18	Indiana	61,010	11,709	.44	5,887	32,080	5.4
22	23	W. Virginia	56,172	3,345	.12	12,800	9,164	.7
23	20	Alabama	37,501	7,493	.28	447	20,529	45.9
24	24	New York	23,106	1,789	.07	13,500	4,901	.4
25	25	Florida	....	418	.01	11	1,145	104.1
26	26	S. Dakota	....	170	....	18	466	25.9
27	27	Nevada	....	137	....	2	375	187.5
28	28	Missouri	90,530	108	.02	111	296	2.7
29	29	Arizona	....	43	....	13	118	9.1
30	30	Tennessee	....	18	....	30	49	1.6
31	31	Virginia	....	3	....	5	8	1.6
		Total	31,389,223	2,676,185	100.00	588,280	7,332,014	12.5

*American Petroleum Institute.
Column 7—Data Provided by World Oil.

the Secretary of the Interior and, as of July 1, 1962, 554 units containing over 8½ million acres were in effect. Upwards of 60% of the production from all Federal lands is obtained from lands subject to such unit agreement. As a means of forming small drilling units from diversified interests, usually for one well and generally to conform to field spacing practices, communitization is permissible with appropriate Geological Survey approval. All administration of unitization and communitization, where appropriate, are functions of the Conservation Division of the Geological Survey and unit plan regulations incident thereto may be found in Part 226, Title 30, of the Code of Federal Regulations.

The Geological Survey, through its extensive surveys published in the form of Professional Papers, Bulletins, Water-Supply Papers, Circulars, Annual Reports, Monographs, Mineral Resources 1882–1931 (replaced by the Bureau of Mines Minerals Yearbook), Geologic Folios, and Maps and Charts, has furnished


UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF OIL AND GAS
ALASKA '60 OF 3 '61 POW 45 '61 B/D 17,329
WASHINGTON '60 OF 1 '60 POW 1 '60 B/D 3
MONTANA '58 OF 70 '61 POW 3,613 '61 B/D 84,677
NORTH DAKOTA '58 OF 64 '61 POW 1,319 '61 B/D 64,570
WYOMING '58 OF 216 '61 POW 7,680 '61 B/D 390,685
SOUTH DAKOTA '58 OF 2 '61 POW 24 '61 B/D 641
NEBRASKA '58 OF 230 '61 POW 1,860 '61 B/D 66,837
NEVADA '61 OF 1 '61 POW 2 '61 B/D 417
UTAH '58 OF 19 '61 POW 908 '61 B/D 90,734
COLORADO '58 OF 305 '61 POW 2,091 '61 B/D 128,071
CALIFORNIA '61 OF 231 '61 POW 38,333 '61 B/D 822,086
ARIZONA '60 OF 1 '61 POW 4 '61 B/D 184
NEW MEXICO '58 OF 233 '61 POW 13,602 '61 B/D 307,077
KANSAS '58 OF 1,645 '61 POW 44,219 '61 B/D 307,510
OKLAHOMA '58 OF 1,679 '61 POW 82,751 '61 B/D 525,573
MISSOURI '61 OF 17 '61 POW 120 '61 B/D 296
ARKANSAS '58 OF 165 '61 POW 6,431 '61 B/D 80,134
TEXAS '58 OF 4,850 '61 POW 196,817 '61 B/D 2,569,910
LOUISIANA '58 OF 872 '61 POW 24,407 '61 B/D 1,164,279
LOUISIANA–OFFSHORE '62 OF 111 '60 POW 1,941 '60 B/D 229,536
MISSISSIPPI '58 OF 178 '61 POW 2,692 '61 B/D 149,293
ALABAMA '58 OF 4 '61 POW 406 '61 B/D 18,992
FLORIDA '58 OF 2 '61 POW 11 '61 B/D 1,016
ILLINOIS '58 OF 496 '61 POW 35,762 '61 B/D 217,500
INDIANA '58 OF 237 '61 POW 5,963 '61 B/D 30,553
MICHIGAN '58 OF 267 '61 POW 4,380 '61 B/D 51,775
OHIO '62 OF 372 '62 POW 14,965 '62 B/D 14,140
KENTUCKY '58 OF 318 '61 POW 20,212 '61 B/D 51,077
TENNESSEE '61 OF 48 '61 POW 30 '61 B/D 49
WEST VIRGINIA '62 OF 154 '61 POW 13,073 '61 B/D 7,805
VIRGINIA '61 OF 1 '61 POW 8 '61 B/D 16
PENNSYLVANIA '58 OF 235 '61 POW 58,972 '61 B/D 15,403
NEW YORK '58 OF 29 '61 POW 17,479 '61 B/D 4,696
HAWAII
UNITED STATES '58 OF 13,056 '61 POW 597,980 '61 B/D 7,182,900
EDGE OF CONTINENTAL SHELF
EDGE OF CONTINENTAL SHELF
EDGE OF CONTINENTAL SHELF
EDGE OF CONTINENTAL SHELF
COASTAL PLAIN
AREA OF CONTINENTAL SHELF
OIL AND GAS FIELDS.
STATES (18) IN WHICH COMMERCIAL OIL HAS NOT YET BEEN DISCOVERED

LEGEND	DENOTES	DATA SOURCE
'58 OF 10	10 OIL FIELDS IN YEAR 1958	AIME STATISTICS VOL. 13, 1958
'60 POW 100	100 PRODUCING OIL WELLS IN YEAR 1960	AVERAGE OF WORLD OIL AND OIL & GAS JOURNAL FIGURES
'61 B D 1,000	1,000 BARRELS OF OIL PER DAY PRODUCED IN YEAR 1961	U.S. BUREAU OF MINES. MONTHLY PETROLEUM STATEMENT NO. 477 DECEMBER 1961

A PRECISE COUNT OF OIL FIELDS OR OIL WELLS IS PRACTICALLY IMPOSSIBLE. FIGURES DO NOT INCLUDE GAS OR CONDENSATE FIELDS, WELLS OR PRODUCTION. FIGURES APPLY TO CRUDE OIL ONLY.

MAP OF THE OIL AND GAS FIELDS OF THE UNITED STATES, SHOWING GULF AND ATLANTIC COASTAL PLAIN AND THE CONTINENTAL SHELVES

World Crude Oil Produution by Countries 1962

Order of production (1)	Country (2)	Production in barrels (3)	Percent of world production (4)
1	United States	7, 332, 014	30.223
2	U.S.S.R. (Russia)*	3, 720, 000	15.334
3	Venezuela	3, 199, 800	13.190
4	Kuwait	1, 855, 000	7.647
5	Saudi Arabia	1, 520, 000	6.266
6	Iran	1, 305, 000	5.379
7	Iraq	998, 500	4.116
8	Canada	690, 000	2.844
9	Indonesia	460, 000	1.896
10	Algeria	435, 000	1.793
11	Mexico	308, 000	1.270
12	Argentina	269, 000	1.109
13	Neutral Zone	236, 000	.973
14	Rumania*	235, 000	.968
15	Qatar	183, 000	.754
16	Libya	180, 000	.742
17	Columbia	139, 000	.573
18	West Germany	134, 000	.552
19	Trinidad	133, 000	.548
20	China*	91, 781	.378
21	Brazil	90, 000	.371
22	Egypt	88, 700	.366
23	British Borneo	81, 500	.336
24	Nigeria	67, 000	.276
25	Peru	59, 000	.243
26	France	47, 000	.194
27	Bahrain	45, 000	.185
28	Austria	45, 000	.185
29	Netherlands	41, 000	.169
30	Italy	35, 000	.144
31	Chile	32, 000	.132
32	Yugoslavia	30, 000	.124
33	Hungary*	28, 000	.115
34	Abu Dhabi	20, 000	.082
35	Gabon	16, 700	.069
36	Japan	14, 500	.060
37	Albania*	11, 501	.047
38	Burma	11, 500	.041
39	India	10, 000	.041
40	Turkey	10, 000	.041
41	Pakistan	9, 000	.037
42	Bolivia	7, 300	.030
43	Ecudor	7, 200	.030
44	Angola	5, 000	.021
45	Bulgaria*	4, 101	.017
46	Poland*	4, 000	.016
47	Morocco	2, 700	.011
48	Czechoslovakia*	2, 600	.011
49	New Guinea	2, 500	.010
50	Israel	2, 500	.010
51	United Kingdom	2, 200	.010
52	Congo*	2, 300	.010
53	Cuba*	300	.012
54	Taiwan*	35	.001
55	New Zealand*	8	—.001
56	Philippines*	6	—.001
	World Total	24, 259, 246	100.000

Source: Office of Oil and Gas unless indicated.

*World Oil.

the basis for much of the exploration which has resulted in the discovery of many oil and gas fields. It is also responsible for many phases of the administration of the numerous acts governing the development and production of this Nation's oil and gas, including unitization, communitization, enforcement of the operating regulations and on site supervision of operations.

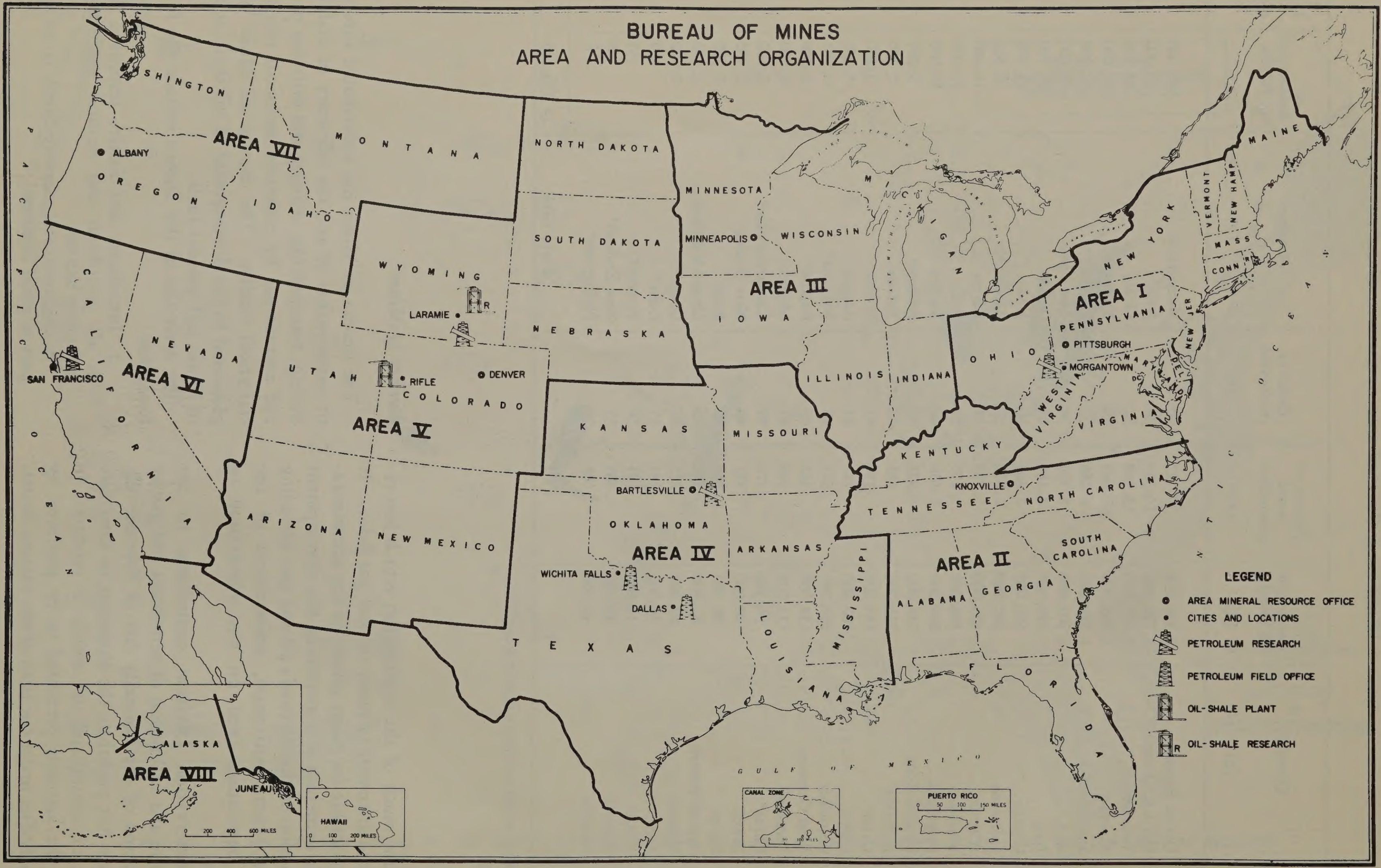
The Conservation Division contributes to the conservation and utilization of petroleum and gas by administration of the Connally Act of February 22, 1935. This Act prohibits the shipment in interstate commerce of contraband oil which is produced in excess of the amounts permitted to be produced by regulatory bodies under the laws of the various States.

Bureau of Mines

The Bureau of Mines has contributed substantially to conservation of and the efficiency of finding, producing, transporting, refining and utilizing petroleum and natural gas by extensive technical research and statistical studies. The Bureau of Mines also has pioneered in the development of oil shale as a source of liquid and gaseous fuels.

The activities of the Bureau include the following functions:

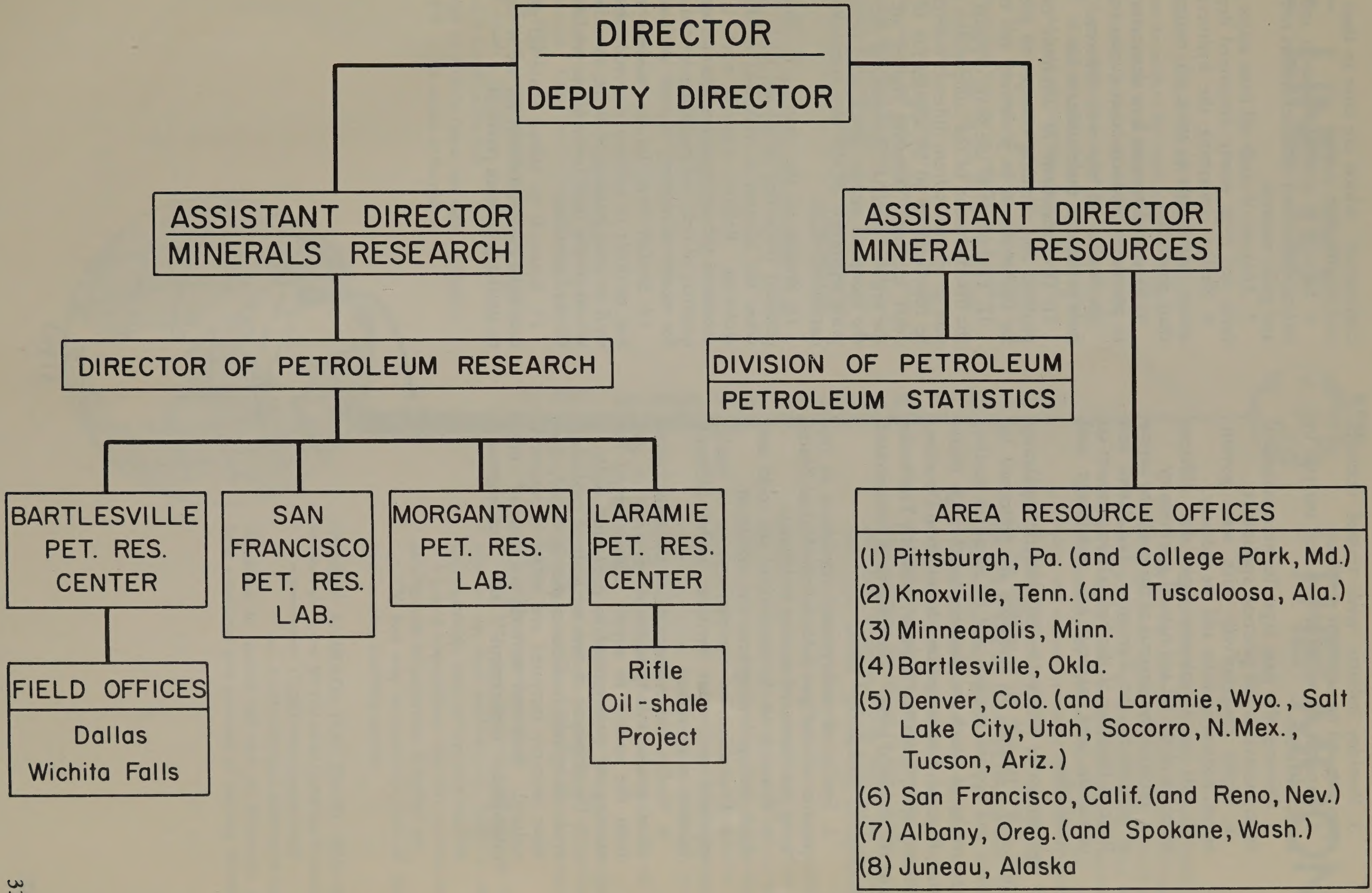
1. Introduces and fosters improved methods in all petroleum and natural gas operations, including helium.
2. Demonstrates that research is an essential part of good business.



BUREAU OF MINES
AREA AND RESEARCH ORGANIZATION

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES


DIRECTOR
DEPUTY DIRECTOR
ASSISTANT DIRECTOR MINERALS RESEARCH
ASSISTANT DIRECTOR MINERAL RESOURCES
DIRECTOR OF PETROLEUM RESEARCH
DIVISION OF PETROLEUM
PETROLEUM STATISTICS
BARTLESVILLE PET. RES. CENTER
SAN FRANCISCO PET. RES. LAB.
MORGANTOWN PET. RES. LAB.
LARAMIE PET. RES. CENTER
FIELD OFFICES
Dallas
Wichita Falls
Rifle Oil-shale Project
AREA RESOURCE OFFICES
(1) Pittsburgh, Pa. (and College Park, Md.)
(2) Knoxville, Tenn. (and Tuscaloosa, Ala.)
(3) Minneapolis, Minn.
(4) Bartlesville, Okla.
(5) Denver, Colo. (and Laramie, Wyo., Salt Lake City, Utah, Socorro, N. Mex., Tucson, Ariz.)
(6) San Francisco, Calif. (and Reno, Nev.)
(7) Albany, Oreg. (and Spokane, Wash.)
(8) Juneau, Alaska

3. Provides industry with trained research, operating and management personnel.

4. Expands the value of tests and analyses by standardization.

5. Shortens the time lapse between successful experimentation and practical application.

6. Works cooperatively with state governments, Federal agencies and the industry.

7. Acts as a cohesive agent for different branches of the oil and natural gas industry.

8. Protects the interests of the public by acting as adviser to the Executive, Legislative and Judicial Branches of the Federal Government on petroleum and natural gas technology and economics.

The Bureau of Mines does not exercise regulatory authority. Instead, its functions are performed by basic and applied research and by resources studies, the results of which are disseminated through Bulletins, Reports of Investigations, Information Circulars, Monographs, Statistical Reports, Minerals Yearbooks and the technical press. The research is concentrated in the following general areas:

1. Studies of underground conditions in important oil and gas fields in the United States using petroleum engineering techniques.

2. Research on the behavior of the rocks and fluids during development and operation.

3. Evaluations of the performance of wells, pipelines and other facilities under different methods of operation.

4. Studies and evaluations of the stimulation of oil production by injection of water or gas from the surface to supply added energy for moving oil underground to producing wells.

5. Development of new methods of producing crude oil by which efficiency may be raised, ultimate recovery increased and waste of resources reduced. Such new methods are those of "miscible-phase replacement" and "underground combustion" which are now in their formative and development stages.

6. Surveys of mineral resources and industry, and economics and statistics studies to supplement and guide research.

7. Analyses of crude oil from major producing fields and from newly discovered deposits.

8. Studies concerning the hydrocarbons and minor constituents in crude oil, natural gas and their products.

9. Tests to determine how detrimental changes to petroleum products occur during storage.

10. Studies of the way different petroleum fuels perform in their ultimate use.

11. Determinations of relations of heat to physical and chemical changes to provide data for improvements in processing and utilization.

12. Evaluation of the shale deposits involving the determination of the composition and structure of oil shales from different sources that can be converted to oil by application of heat and other methods. Separate studies are made of the organic material (kerogen) of the shale and the inorganic matter (shale ash) which involve prior separation of the two components of the natural oil shale.

13. Studies of the changes in chemical and physical properties of the oil shale that result when the kerogen is converted to shale oil by retorting. Related research work is done to determine the optimum temperature required and quantity of heat and operating conditions needed for maximum recovery of crude shale oil.

14. Studies that develop various techniques and methods of refining the crude shale oil, as well as combinations of them, in order to learn which are the most favorable to produce different finished products.

15. Research on refined shale oil products to determine their suitability for use as supplements to similar petroleum products.

PIPE LINE TO THE MOON!

This imaginary 15 foot (14.831′ exact) diameter pipe line from the earth to the moon, a mean distance of 238,857 miles would, as of Dec. 31, 1961 just hold our (United States) proved recoverable reserves of total liquid hydrocarbons (crude oil plus natural gas liquids) of 38,807,601,000 barrels of oil. This pipe line would hold 162,472 barrels of oil per mile.

Our yearly average production of total liquid hydrocarbons for the past 10 years (1952–1961) has been equivalent to using or withdrawing from this pipe line 17,063 miles of oil or 2,772,257,200 barrels of oil per year.

Our yearly average additions to reserves for the same 10 year period has been equivalent to putting in to this pipe line 21,134 miles of oil or 3,433,754,000 barrels of oil per year.

The 10 year average yearly input has exceeded withdrawals by 4,071 miles of oil or 661,496,800 barrels of oil per year.

The source of reserve and production figures is the American Petroleum Institute.

HOW MANY BARRELS PER MILE WILL A PIPE LINE HOLD?

Here is an easy formula to remember. Square the pipe line diameter (in inches), multiply by 5 and you have the answer.

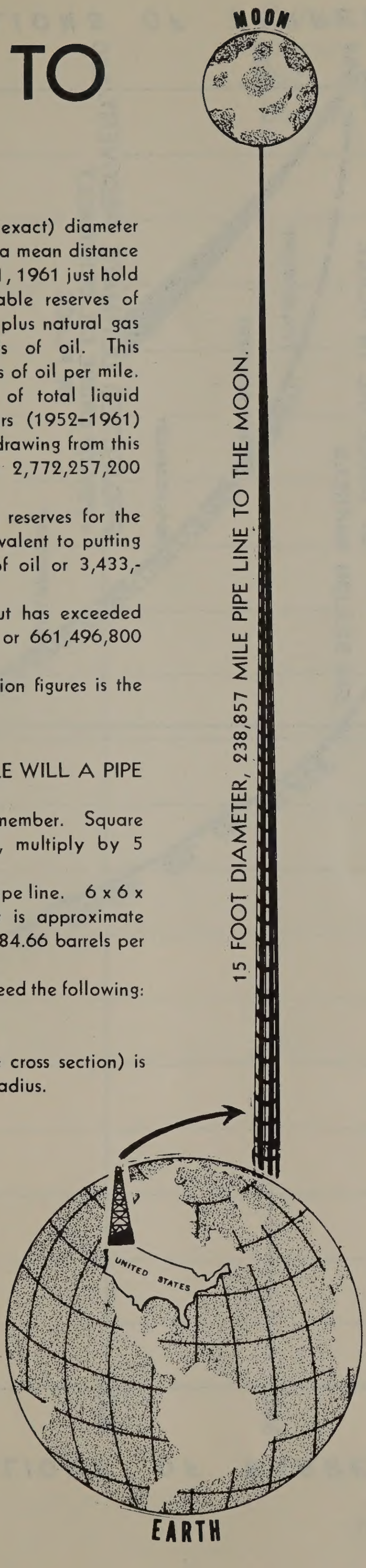
EXAMPLE: For a 6 inch diameter pipe line. 6 x 6 x 5 equals 180 barrels per mile. It is approximate but good enough. Exact figure is 184.66 barrels per mile. (Error 2½%)

To check computations hereon you need the following:

1 mile equals 5,280 feet.

1 barrel is 5.6142 cubic feet.

The area of a circle (pipe line cross section) is 3.1416 × the square of the radius.


MOON
15 FOOT DIAMETER, 238,857 MILE PIPE LINE TO THE MOON.
UNITED STATES
EARTH

PROVED RESERVES OF CRUDE OIL—DEFINITION

These are the volumes of crude oil which geological and engineering information indicate, beyond reasonable doubt, to be recoverable in the future from an oil reservoir under existing economic and operating conditions. They represent strictly technical judgments, and are not knowingly influenced by policies of conservatism or optimism. They are listed only by the definition of the term "proved." They do not include what are commonly referred to as "probable" or "possible" reserves.

The proved reserves may be considered as the known and established underground working inventory available for recovery under prevailing conditions. These estimates are subject to future revisions, either downward or upward, even though the presently established "proved" reserves may be accurate, in the light of current information.

Both drilled and undrilled acreage are considered in the estimates of the proved reserves. However, the undrilled proved reserves are limited to those drilling units immediately adjacent to the developed areas which are virtually certain of productive development, except where the geological information on the producing horizons insures continuity across the undrilled acreage.

The proved crude oil reserves estimates do not include:

1 Oil whose recovery is subject to reasonable doubt because of uncertainty as to geological conditions, reservoir characteristics or economic factors.

2 Oil in untested prospects.

3 Oil that may become available by fluid injection or other methods from fields in which such operations have not yet been applied.

4 Liquid hydrocarbons that may become available through the processing of natural gas.

5 Oil that may be recovered from oil shales, coal or other substitute sources.

YEARLY AVERAGE FOR YEARS 1952–1961.

——————— 21,134 miles (addition to reserves)

————— 17,063 miles (production)

— 4,071 miles (net addition to reserves)

Additions to reserves are new oil discoveries plus field extensions plus revisions of previous estimates.

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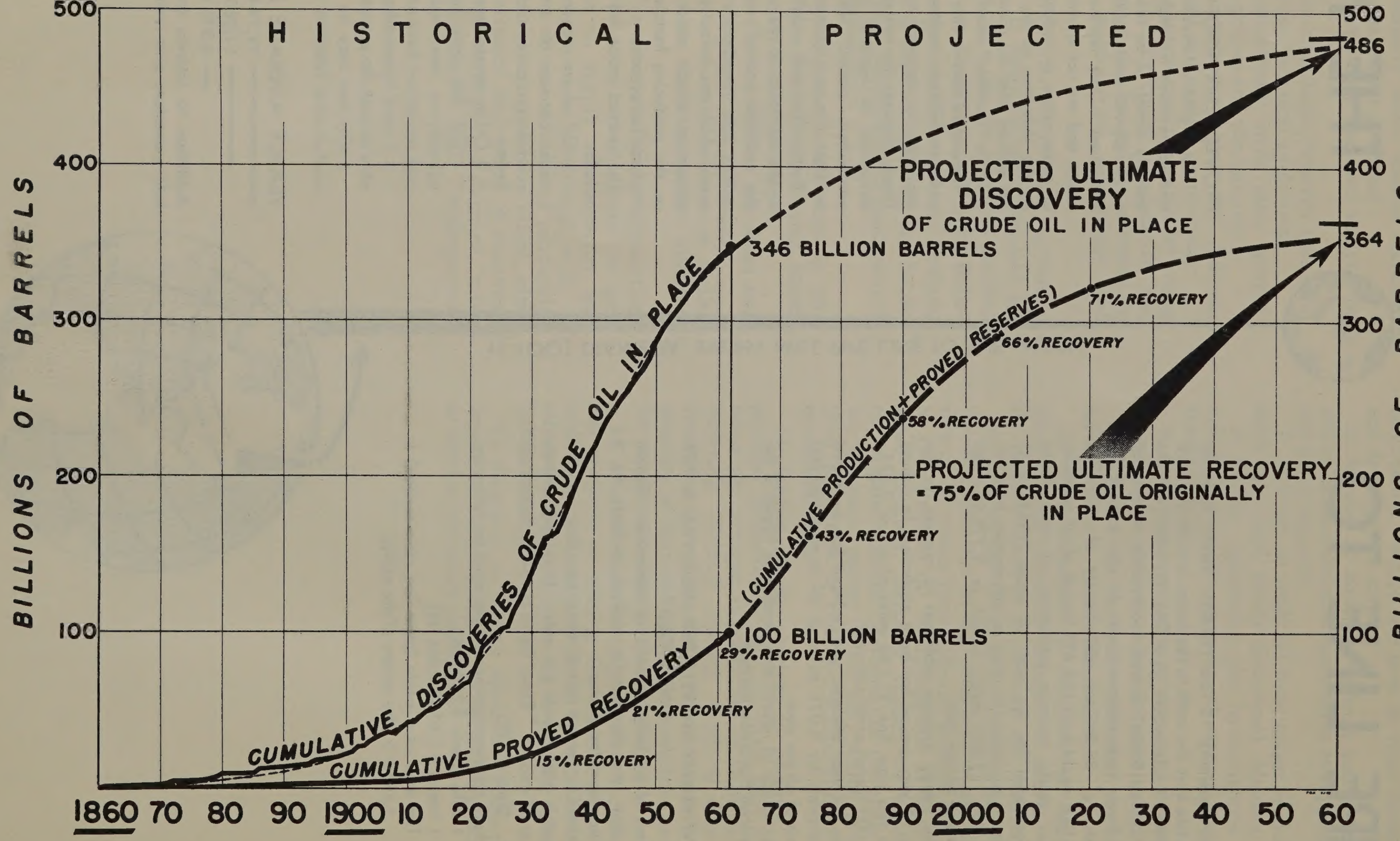
UNITED STATES
CUMULATIVE DISCOVERIES OF CRUDE OIL IN PLACE AND OF CUMULATIVE PROVED RECOVERY 1860-1961 WITH TENTATIVE PROJECTIONS TO 2060



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